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ETI
ELECTRONICS
TODAY INTERNATIONAL

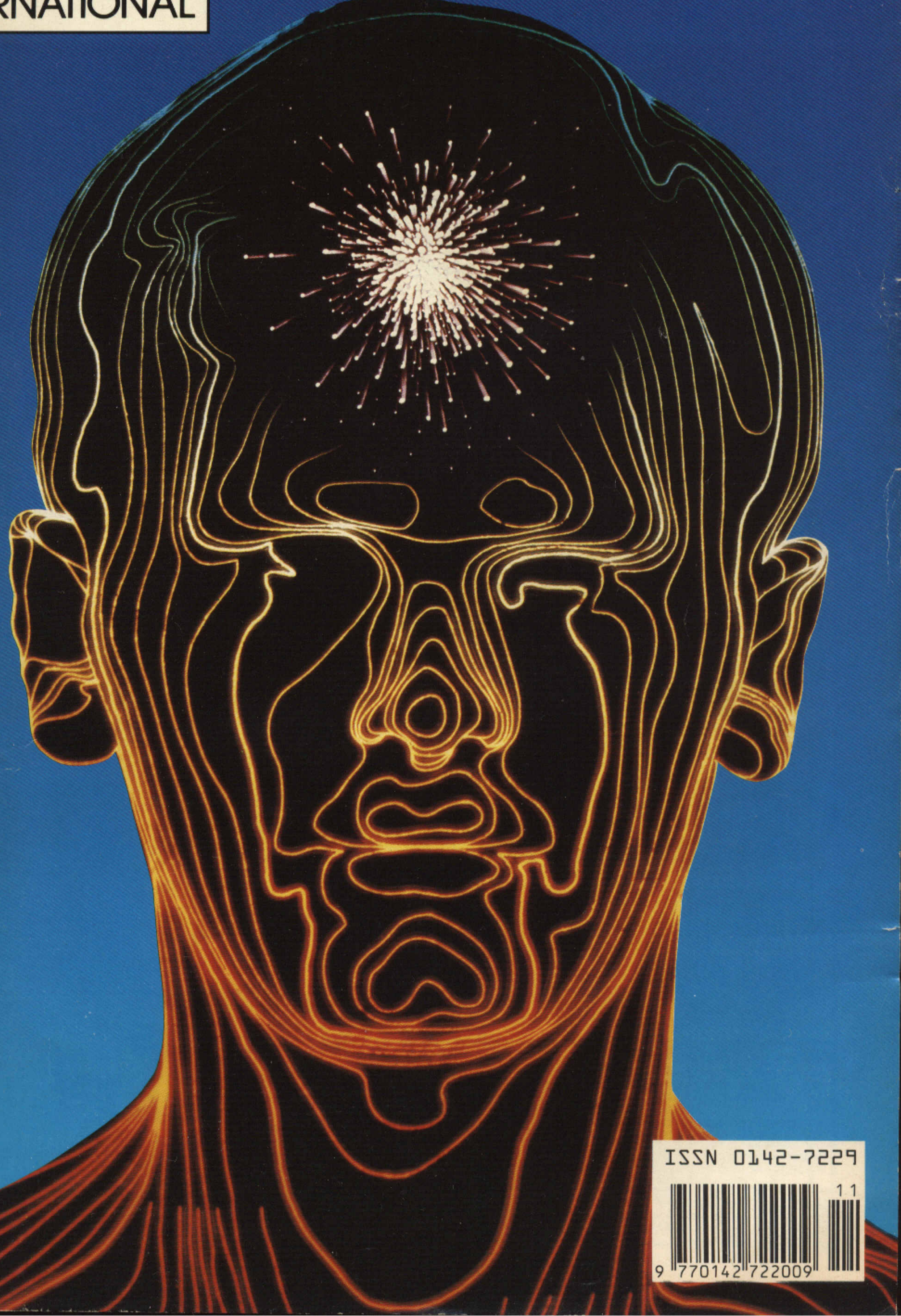
THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

NOVEMBER 1989 £1.50

INTELLIGENCE REPORT

Neural Network Computing Explained

ROCK
circus



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under surveillance . . . news + reviews . . . serial logic scope . .

smoke alarm project . . . frequency meter project . . . inside . .

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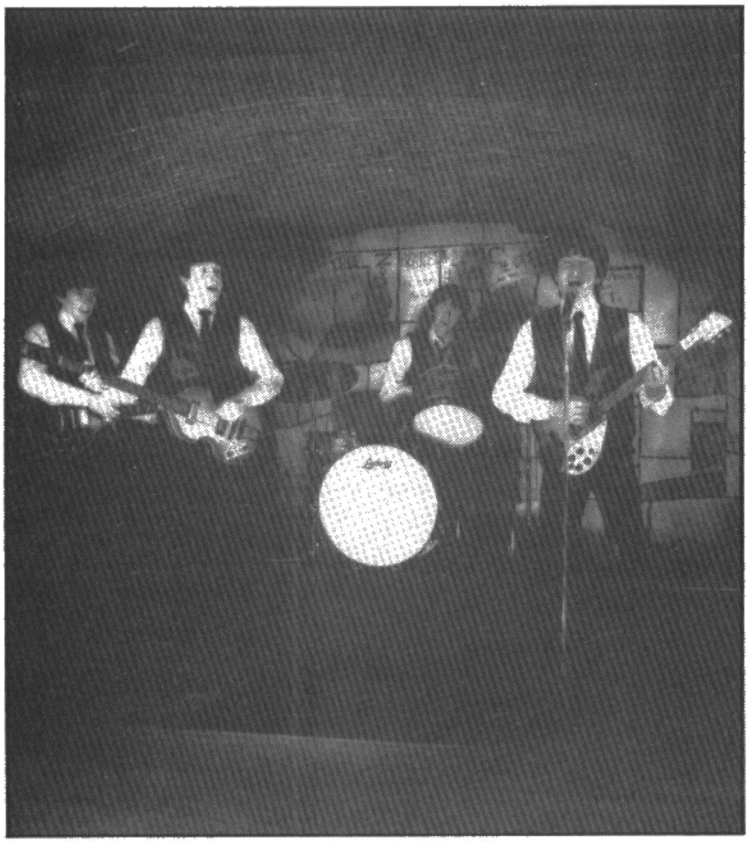

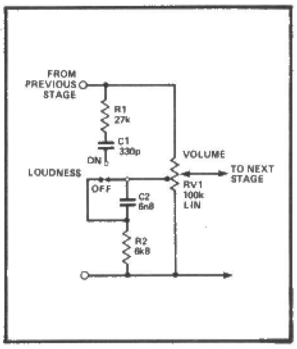

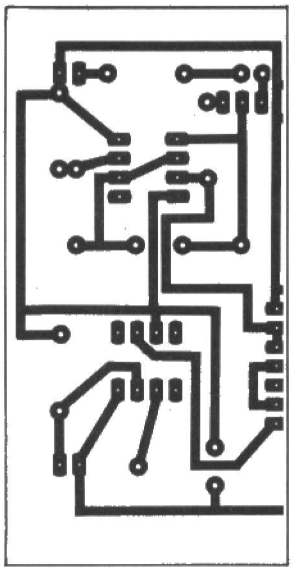

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ELECTRONICS
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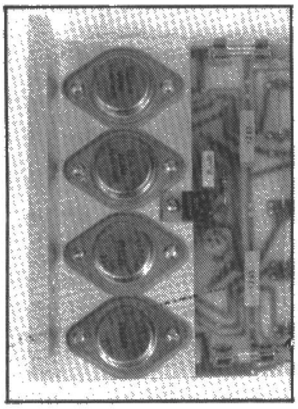

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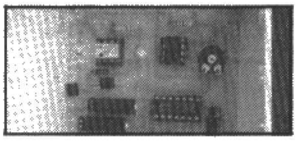

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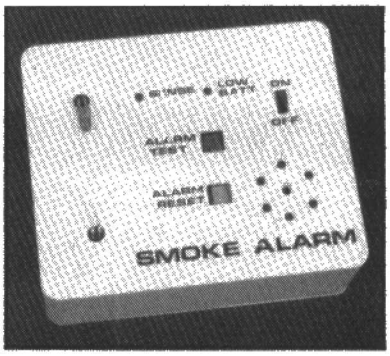

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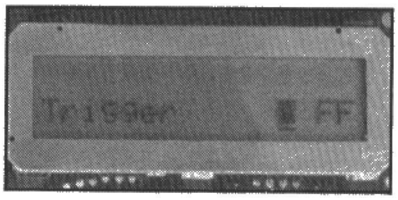

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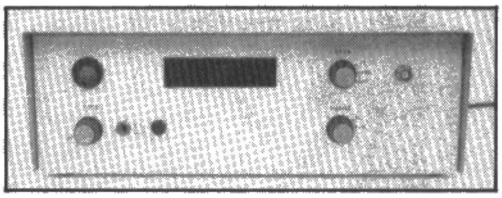

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NEWS

ENTER THE MISFETS

Philips research laboratories in Eindhoven, Holland have demonstrated another new type of transistor.

It's called a Metal-insulator-semiconductor field effect transistor (MISFET) and contains the now celebrated material, gallium arsenide (GaAs). The new GaAs-GaAlAs heterojunction displays a negative differential resistance at room temperature and the discovery opens the possibility of a new range of analogue and digital integrated circuits using GaAs.

The new technology will considerably simplify conventional MOSFET circuitry. One example of this is that a MOSFET exclusive NOR gate typically uses eight transistors and five load resistors whereas the new MISFET gate would employ two resistors and one transistor with its load resistor — a significant reduction.

The MISFET has two distinct advantages. Firstly, its structure is simpler with only one junction and secondly there is a clear negative resistance region which could have special importance for certain analogue applications such as frequency doublers.

Philips stresses that the results achieved are still at laboratory level and manufacture is a long way off.

NICAM ON

IBA Television transmitters covering the London area and parts of Yorkshire have become fully operational for NICAM digital stereo sound on both ITV and Channel 4.

The high quality stereo sound (NICAM 728) has been developed jointly by the broadcasting and receiver manufacturers. NICAM digital stereo will increase the fidelity of music, drama, sports and talk shows. The digital coded system will find its way into your TV set giving high quality sound, comparable to compact disc.

The system is designed to be fully compatible with existing mono sets. NICAM TV sets and VCRs are now readily available and it is hoped that stereo transmissions will reach 75% of the population by the end of 1990.

PROOPSCOOP

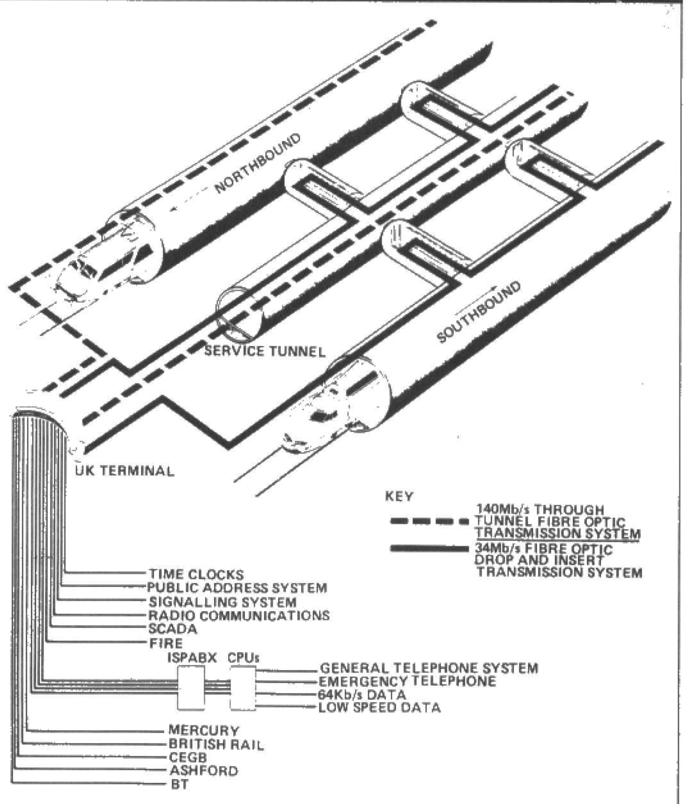
Proops Distributors Ltd of Camden Town are opening their warehouse to the public.

The warehouse contains a wide range of electronic surplus items and will be open six days a week for the sale of high and low tech items, often at a fraction of the usual cost.

During its 30-year trading in Tottenham Court Road, Proops brothers attracted enthusiasts from all over southern England and a significant number from overseas. When the shop closed last year many hopeful customers started visiting the warehouse. It was due to this demand that the warehouse was opened to the public.

Proops can be found in Castle Road, Camden Town, London and is open 9.00-5.00 weekdays and 10.00-2.00pm Saturdays.

TUNNEL VISION



The channel tunnel is to be equipped with voice and data communication systems by 1993.

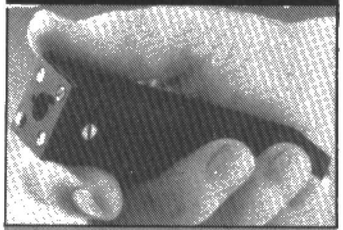
The £20 million contract has been awarded to Racal-Milgo Ltd to produce a system design for data transmission, telephone and public address for the tunnel. It is to be installed and finished before the tunnel is opened.

The teams assembled by Racal make the project a joint venture between an equal balance of British and French companies.

High speed fibre optic digital signals will run the whole length of the three tunnels and will transmit data at rates of 140 Mbit/s. As so many different types of message are to be sent down these light guides, many hundreds multiplexers will be employed to handle the mass of information.

Data content will include such mundane things as administration to the all important signalling of this high speed rail link.

LAMBDA LIGHT



Lambda Photometrics is launching a modular, sub-miniature visible laser system.

Measuring only 25×25×100mm, the hand-held laser incorporates lens centering and focus adjustment with an integrating feedback loop to maintain constant light output.

The unit will accept a specification range of your choice depending on its application. It also requires a 12V DC supply.

Further information can be obtained from Lambda Photometrics, Tel: (05827) 64334.

CALLING THE RECEIVER

Panasonic has released its latest multi-band portable radio.

The set offers many features for the globe-trotting listener including single sideband for the short wave. SSB (as it's known) is being used more and more by broadcasters because of its greater operating efficiency.

Sensitivity, stability and selectivity are achieved using a micro-controlled phased lock loop detector with quartz synthesis tuner to keep the receiver locked in to the station.

Station frequency can be tapped in to the numeric keypad for easy tuning. Alternatively, auto scan tuning allows each station to be heard in sequence down the band. Fine tuning can also be made with a rotary dial.

The radio has a standard clock alarm with a dual time clock facility to keep pace with other time zoned radio programmes in the world.

The RF-B65D retails at £179.95.

Further information tel: (0344) 862444.

COMPUTING WITH BRAINS

The first international conference of Artificial Neural Networks takes place in London on 16-18 October 1989.

The subject has attracted considerable attention (even in this issue of ETI) and the conference will bring together researchers from Europe, the USA and Australia.

Major neural network architectures will be reviewed along with their associated applications in vision, image processing, speech, signal and data processing. There will also be progress reports on the hardware implementation of neural networks within VLSI electronics.

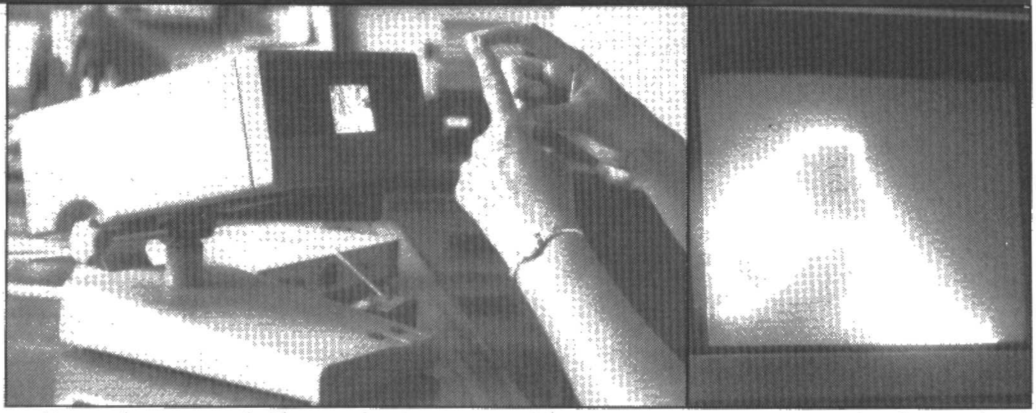
Copies of the conference programme and registration details are available from: Conference Services, IEE, Savoy Place, London WC2R 0BL.

TELECOMMUNICATION — BY HAND

BT has produced a unique system of moving 'cartoon' pictures to allow deaf people to communicate over the telephone network using sign language.

The system is still at the experimental stage but is believed to be the first of its kind anywhere in the world.

About a quarter of a million people suffer from hearing loss in Britain and as many as 50,000 use sign language so that a telephone system using visual communication would be of benefit to them. The equipment has been designed by scientists at BT's research laboratories and at the University of Essex.



So far, experimental trials using sign language over the phone have been successful. The equipment is based on the experimental videophone developed at the BT laboratories some time ago. The phone combines a video camera and a 60mm square TV screen.

For the new system to operate, the signal has to be compressed in order to be carried down a 4kHz telephone line. The image coded algorithms, developed at Essex University reduce the picture content information to a point where it can be sent through ordinary phone lines at a rate of 14,400 bits per second. The resulting black and white picture, referred to as a cartoon, is reduced to an outline depicting facial characteristics and more importantly, showing hand movements in real time.

Larger scale trials are now being planned involving as many as 50 participants but any commercial product is thought to be many years away.

BE THERE OR BE SQUARE

With BSB's satellite Marcopolo 1 now up and in geostationary orbit 23,300 miles above the equator, concern still mounts as to whether the mass production of associated electronics and an on-air launch date can be met.

BSB now hopes a spring launch date will buy extra time for the completion of the descrambling chip developed by ITT and to the mass production of the much awaited squarial.

Much development has gone into the new TV technology that BSB will adopt. They are using a British development of Multiplex Analogue Component for broadcasting (D-MAC) and it gives some distinct advantages over all its rivals using the PAL system (which includes Sky TV). The picture quality is greatly improved and removes several old problems inherent in the PAL system, one being the herringbone patterns or cross-hatching that came from finely striped colours.

Accompanying the picture comes high quality stereo sound — though this is not such much an advantage because NICAM stereo is now accompanying the PAL signal. D-MAC can also handle the capacity of up to eight high quality digital audio signals and data channels. Flow rate for data is at 3Mbit/s if the TV channel is being broadcast or at 20.25Mbit/s without TV.

The launch of a second satellite this year for BSB will mean that the two can provide five TV channels to the squarial.

With incompatibility between the types of transmission systems for BSB and Sky, it remains to be seen whether the public will accept both, one or none at all.

CT2 ON THE RAILS

BR has given the go-ahead for CT2 or Telepoint, the new portable phone system, to be installed into its 2400 stations.

The handsets can make outgoing phone calls only (ETI News Sept) provided they are within 200 metres of a base station.

BR has signed deals with several operators, including Phonepoint, a consortium led by British Telecom.

Phonepoint, the first to launch the service, has also made deals to place bases with the Post Office, the Automobile Association, London Buses, Manchester Airport and motorway service stations. This should bring the number of sites available to 36000.

Phonepoint's intention is to have a base station every 500m in city centres and at points along main roads. Progress will be slow as Phonepoint intends to have only about 4000 bases in two years.

Four rival companies have been licensed for the CT2 system, each developing their own system. But these are not compatible at present until a government ruling comes into force at the end of 1990 which states they must all use the same signalling standard called Common Air Interface (CAI). The benefits to the public will be the choice of buying any phone and then registering with only one network.

Each of the four operators will have its own charging structure just to add to the confusion. Telepoint operating charges will be cheaper than cellphones, being about a third of the cost. The handsets are also compact and cheaper than their cellular counterparts.

Manufacture on a large scale could see the price falling as low as £50 if Europe adopts the same type of service.

WILMSLOW OF KNUTSFORD

Wilmslow Audio has moved from its base in Wilmslow, Cheshire to a new building in Knutsford. There the company has improved facilities including demo rooms to present its range of quality speaker kits and drive units to the public.

The full address is Wilmslow Audio, Wellington Close, Parkgate Trading Estate, Knutsford, Cheshire WA16 8DX. Tel: (0565) 50605.

SMART BANKING

Smart cards, those pieces of plastic containing microchips are now being investigated for a variety of uses by Barclays Bank.

Smart cards are being used for financial transactions in France and as we reported in September, Sky intends to use them to unscramble satellite TV broadcasts. Now it appears that Barclays Bank are finding more practical uses for them like gaining access to leisure clubs.

KEEPING TRACK

New opportunities exist for the railway industry now the popularity of flying has become increasingly dogged by delays.

Plans are in the tunnel for new high speed rail links across Europe and also within Australia, but a choice exists in the technology to be employed — should it be a magnetically levitated train or should the more conservative option of wheel on steel be adopted?

Like the Japanese, the West Germans are seriously thinking of adopting Maglev for parts of their network. The trains hover by magnetic repulsion on elevated track and offer minimal resistance owing to their streamlining. The trains are propelled forward by magnetism using the linear motor principle. The obvious advantage of magnetic levitation is one of speed — 500kmh would be typical of these trains and it would get you there with the gliding comfort of an air journey.

The drawbacks are the all important costs and the incompatibility with existing rail networks.

Meanwhile Australia is going for more conventional steel on wheel technology. The proposed Very Fast Train (VFT) has a top speed of 350kmh and if laid between Sydney and Melbourne, the journey would take three hours and offers a cheaper more attractive alternative to air travel.

With its own dedicated standard gauge track it will have steeper gradients than conventional railways. The reason is that the train will climb hills more easily owing to its high kinetic energy. This has led to a marked reduction in construction costs.

Other interesting features include the usage of overhead cable at 1500V DC in town to avoid electrical interference and 50,000V AC elsewhere and three braking systems — electrical, magnetic and conventional discs.

The Australian decision for conventional technology is mainly one of cost. Maglev systems coming out at two and a half times greater. The situation will be reviewed in 30 years time when the cost ratio becomes more favourable.

READ\WRITE

ETI LETTERS

CDs — An open letter to the Recording Industry

In the seventies, giant leaps in hi-fi system technology took place from the basic music-centre type system. These included metal tapes, Dolby, moving coil cartridges, quartz locked DC motor turntables, synthesis tuning receivers, MOSFET-based amplifiers, ferro-fluid tweeters and a myriad of various poly-based loudspeaker cones.

In the midst of all this we also suffered an appalling standard of pressing quality on most records, albums in particular. We saw the record industry get their knuckles severely rapped resulting in a considerable improvement in record pressing quality and surface noise in an attempt to save the record industry's profits amidst the evermore popular cassette tape medium.

Are we now to repeat such a fiasco in the eighties and nineties with compact disc? There again has been a mega-leap forward for sound reproduction with CD players costing from as little as £50 up to £2500, the average being around £200. They sport advanced features such as multi oversampling, bit multiplication, digital pulse axis control plus all the user orientated remote control functions and programmable track play. We are promised 100dB or more of signal-to-noise ratio, −95dB harmonic distortion, zero crosstalk + wow + flutter, zero hum and superb frequency response.

Why then is it that after paying all this money for the latest digital CD player do we find that not one CD in the charts even nearly approached the performance of even a standard player?

I have found that the typical signal to noise on many chart CDs is a little over 60dB (about the same as a good record). In addition, some have low levels of 50Hz hum (again typically −60dB) something that should have been banished from all recordings years ago. The best CD I could find (Paul McCartney, 'Flowers In The Dirt') clocks in a mere 75dB signal-to-noise ratio some 25dB short of the promised magic 100dB.

The current state of CD recording quality makes complete nonsense of the latest state of the art technology fitted to current CD players. CDs are also not particularly cheap and I believe the public are being totally misled by the promised improved quality when the quality of recordings are so poor. So I ask the recording industry to put some of those huge profits back into refurbishing recording equipment up to a standard that at least matches today's hi-fi systems.

Les Sage
Sage Audio Electronics
Bingley
Yorks

Working on many levels

I think Mr Linsley Hood is doing a good job popularising the concepts of energy bands in the theory of semiconductors (ETI September) if his readers are already vaguely familiar with the ideas. Indeed the subject ought to be explainable to a child if only one step were not left out — where do 'energy bands' come from?

The conceptual step from energy *levels* in isolated atoms to energy *bands* in condensed matter (usually in the solid state) is easily explained in my simple diagram (see Fig. 1).

As the separation between atoms decreases, their outer shells overlap, interact and perturb one another whilst sharing electrons in forming a 'molecular orbital' with 2,3, . . N, . . energy levels. If N is large (about 10^{23} atoms in $1cm^3$) the energy levels are so close together (compared with the ambient thermal agitation energy kT at room temperature), they can be regarded as a *continuous* band.

The theory Mr Linsley Hood described then follows on from there. (The next step backward from there is to ask where do energy levels come from in atoms — energy exchanges in the e^+e^- aether).

Electrons are trapped in the system yet are susceptible to external stimuli to store energy by occupying unused energy levels in the conduction band — and conduction is continuous to all energy levels up to the ionisation or 'work function' energy of the material.

The reason the energy levels perturb is usually called the Pauli exclusion principle, that no two electrons in a system may possess identical quantum numbers describing their electron charge-density probability distribution. This simply means they may not occupy the same physical space, that they have physical space, that they have physical volume *excluding* one another (unlike mere vibrations) and are classified as Fermions, obeying the Fermi-Dirac statistics for filling energy levels up to the Fermi level at O°K (these stats actually define the Fermi level).

So in filling an isolated atom's energy levels first there is electrostatic repulsion separating electrons on the same energy level (but different geometrical distribution) into single electrons. Then the weaker magnetic coupling forces them to pair spins as the only remaining low-energy option for stable neutrality.

This explains the extremely high paramagnetic properties of the earlier 4d transition elements in the periodic table producing ferromagnetism and remnant magnetism in crystal arrays cooled below a critical thermal coupling constant (Curie temperature). In the theory of superconductors electrons are supposed to pair spins (Cooper pairs in classical BCS theory) in molecular orbitals (energised currents) that persist throughout the material structure in the absence of any thermal disruption — though this theory has been brought into doubt in recent years since the discovery of high temperature superconductors fabricated from ceramic mixtures.

The theory of finite-N energy bands is of interest in developing higher density molecular memory devices in the coming years (using about N = 20 atoms).

The same theory enables us to understand how hydrogen can become metallic under extreme pressure and low temperature, by perturbing the energy levels in an array of atoms so much that the valence band overlaps the conduction band.

Obviously the mathematical theory of wave mechanics is too complicated for schools, but a qualitative description should be easily appreciated by literally everyone if the high ideals of the standard curriculum are realised in good textbooks (to help the teachers too). As to a definition of 'good' it has to communicate *ideas* without the central information being lost in the sophistry of slick gloss. You can bet however there will always be a two-tier system of knowledge monopolising understanding for the elite — ouch bite your tongue! You imagined that it didn't happen.

Yours sincerely,

P. J. Ratcliffe
Stevenage, Herts.

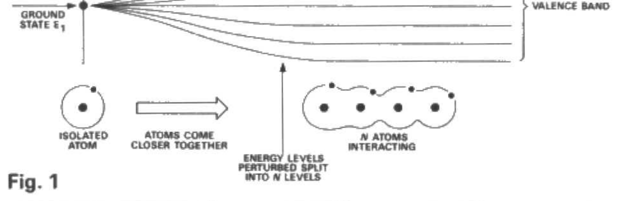


Fig. 1

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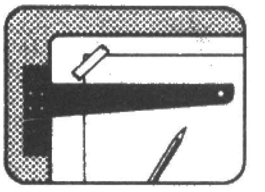

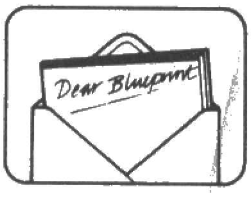

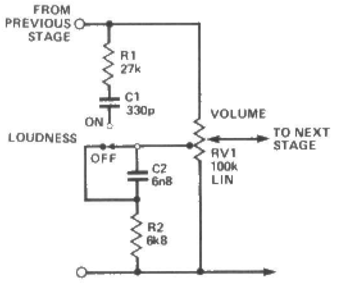

Fig. 1

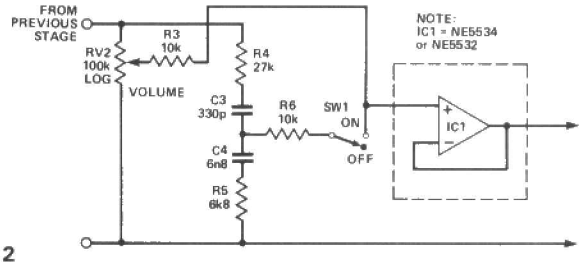

Fig. 2

This month I had intended to report on the testing of the amplifier system for the shearwater sanctuary (see opposite), but events including a defective item of computer hardware have delayed everything, so that the amplifier is likely to be complete and tested several days after the publication deadline. I shall report on this next month, and deal with a different audio subject this month.

Mr D J Bruyns of Port Shepstone writes to ask if it is possible to build a loudness control onto a hi-fi amplifier without using a tapped volume control. He has added a loudness control using a tapped potentiometer to a preamplifier for his ETI MOSFET power amplifier but finds that the sections of the pot do not track. He would prefer to use an untapped potentiometer of higher quality and have the loudness control totally separate.

To answer this question, we must first consider the normal way in which a loudness control works. Fig. 1 shows a typical circuit using a tapped potentiometer. A linear potentiometer is used with R2 providing loading to the centre tap to give a piecewise linear approximation to a log characteristic. The switching is arranged so that this loading takes effect whether or not the loudness function is switched in. When it *is* switched in however, signal with a modified frequency response characteristic is applied to the centre tap.

Frequency Response

When the loudness switch is in the 'on' position, R1 and C1 feed a controlled amount of extra high frequency signal to the tapping on the volume control of the potentiometer. It is not possible to provide extra bass without complicated circuitry, so C2 and R2 cut middle and treble by a controlled amount, leaving only the bass unaffected. The net effect of all this is to cut the middle frequency range leaving the extremes of bass and treble unattenuated.

When the loudness switch is turned on, however, the overall volume does not reduce because switching on the loudness cuts the loading to the centre of the pot. Clearly, the effect of the frequency shaping is much greater when the wiper of the pot is below the tap and reduces steadily as the control is advanced beyond the tap. The purpose of this is to provide extra treble and bass only when the volume setting is low, and to diminish this effect as more realistic listening levels are reached.

The snag with this, apart from the need for a tapped pot, is that the amount of boost and cut will only be correct in terms of the response of the ear with one particular relationship between signal input level and loudspeaker efficiency. Thus, for example, if the whole system is accurately set to match the ear's response curve on say the tuner input setting, it will not match the CD input if that is at a different level.

The problem is further complicated by the fact that the intention is to compensate for the reduced sensitivity of the ear to the extremes of the audible frequency range at low sound levels, in order to make music sound more natural than it otherwise would if it is played too quietly. While the hi-fi purist may not go along with the idea of loudness compensation, the perfectionist would wish to apply it as accurately as possible, which the tapped pot does not do.

There is one simple way to provide loudness compensation, which does not require a tapped potentiometer, but which does suffer from the other drawback of inaccurate compensation. This method is shown in Fig. 2, and is often used in cases where an amplifier must be repaired and a tapped potentiometer is unavailable. It has no great virtues, except that it works better than nothing.

The circuit shown in Fig. 3 provides separately variable loudness which can thus be adjusted to suit the program material and the listener's ears. It uses the same loudness compensation network as the other two circuits, but simply adds frequency shaped signal to signal with flat frequency response to vary the overall characteristic.

General points: the op-amps used in these circuits, the NE5534, and its dual version the NE5532, are chosen because they are low-noise devices with very low distortion, plus they do not have some of the audio problems of other op-amps. 741s most emphatically will not do.

Turning up bass and treble controls to simulate loudness compensation does not work very well in most cases, because the frequency response of Baxendall tone controls does not match the ear's response curve as well as a specially designed loudness control.

Andrew Armstrong

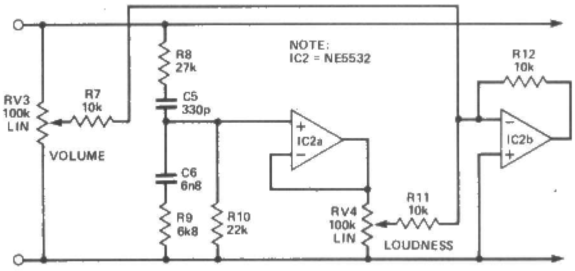

Fig. 3

NEWSAGENT'S NAME ....

NEWSAGENT'S ADDRESS ....

....

NEWSAGENT'S TELEPHONE No. ....

ETI IN STOCK rarely ☐ never ☐

OTHER ELECTRONICS MAGAZINES IN STOCK? yes ☐ no ☐

OTHER SPECIALIST MAGS AVAILABLE
eg computers, radio, CB etc yes ☐ no ☐

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Bear in mind that ETI comes out on the first Friday of the month and a natural break occurs at the end of each period.

INSIGHT

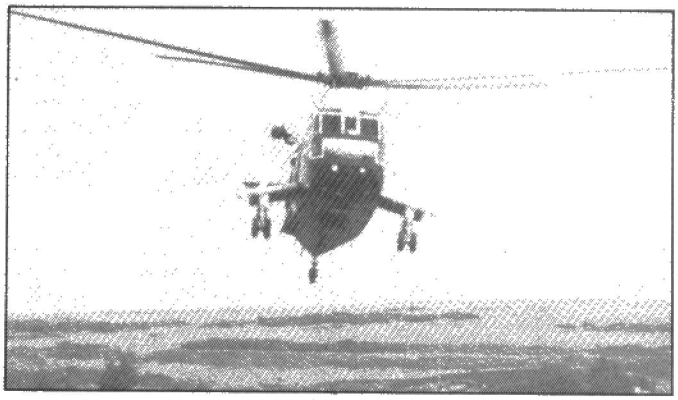
DYFED
WILDLIFE
TRUST

As announced last month in Andrew Armstrong's Blueprint column, ETI has become involved in the Dyfed Wildlife Trust's struggle to establish a breeding colony of Manx Shearwater sea birds on Cardigan Island.

This island offers a rare opportunity to re-establish colonies lost during this century, as the cause of the demise of the threatened birds on the island — rat infestation — has now been eliminated.

Andrew Armstrong is designing a special low-voltage amplifier that will amplify shearwater bird-calls each night through the breeding season, in the hope that this will encourage birds to return.

The equipment — solar cells, a special recorder from Racal Recorders, Deta-Leda batteries and so on — cannot be taken to the island by boat as the sea and rocks combine to make the voyage and landing hazardous for crew and impossible for equipment. Airlifting is the only solution. The first lift was scheduled for August 15th. Mick Baines of the Dyfed Wildlife Trust takes up the story.



Dawn broke on Monday 14th with clear blue skies and little wind. High water was around 6 am and in preparation for that afternoon's meeting on the island, I crossed Cardigan Bay in my 10ft inflatable boat and beached it in a cove near the Cliff Hotel.

Within minutes the wind gathered strength to gale force. It continued to blow hard for three days, whipping the sea up into dangerous surf. The boat remained stranded for the duration of the exercise.

On Tuesday morning, the day of the airlift, the Visnews TV crew arrived at the Cliff Hotel and walked down the coastal path to stare helplessly at the pounding surf. Ferrying the crew to the island was too risky.

I called Rod Penrose of the Trust up on the CB and relayed the disappointing news. By that time he had been joined on Poppit beach by Flight Lieutenant Allen Snowball, the RAF ground crew for the Sea King helicopter. He called up Aberporth Air Traffic Control from his well-equipped Landrover, and they in turn put us onto the pilot of a SWEB Bell Jet-Ranger operating from the airfield. There was just a chance that we might be airlifted onto the island in that aircraft.

We joined the gathering throng on Poppit sands for interviews with the BBC, HTV and Visnews. Then Rod, the Visnews cameraman and I took the equipment up to Aberporth for a trial lift by the Sea King.

The SWEB pilot was in the control tower with the RAF crew and readily agreed to ferry the Visnews cameraman and myself onto the island. Initially there was talk of hundreds of pounds per hour plus VAT! But after a little discussion he brushed aside all talk of payment and promised us a free lift.

First attempts to lift the equipment in a net brought Rod to the verge of a coronary but the problems were soon overcome. From the air the ancient field systems on the island stood out clearly. Our pilot carefully edged the Soay sheep away from our agreed landing point and settled the SWEB down gently on the island, in spite of the howling gale that buffeted the helicoptor.

Lieutenant Dick Ormshaw flew his Sea King over the island to check our position before carrying out a faultless lift from the beach in front of TV crews and scores of onlookers.

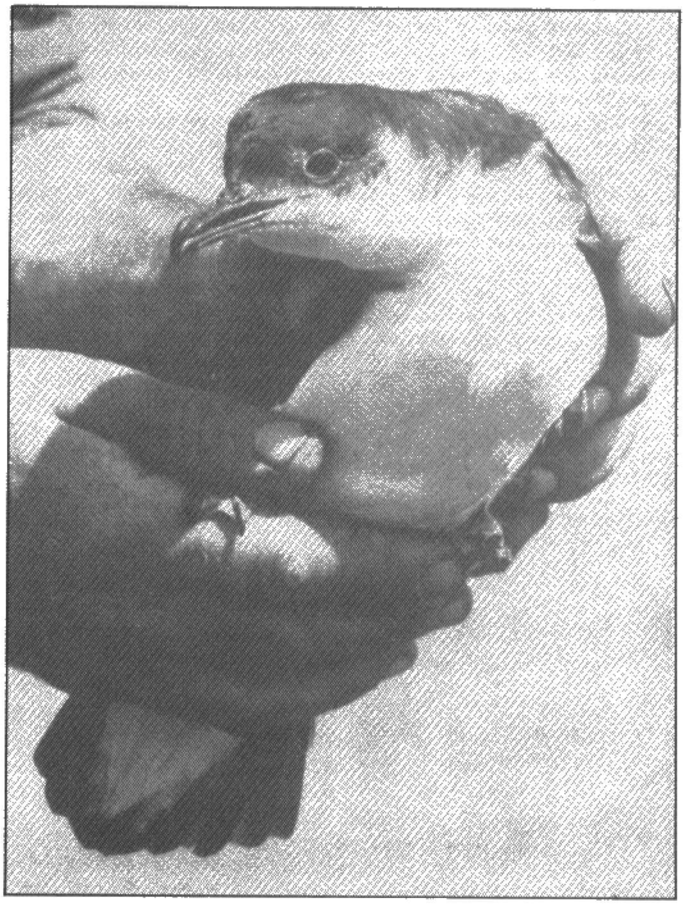
The flight out to the island took less than a minute, but then began the difficult manoeuvre of turning the big machine into the wind and gently winching the load down onto the western summit of the island. Once they had rested the solar-powered equipment on the ground, the winchman paid out the slack so that the pilot could put his helicoptor down to one side, still attached to the load. The crew jumped out and we all helped lift the cabinet, weighed down by heavy batteries, off the net.

With the net gathered back into the machine, the Sea King flew off at high speed to execute a spectacularly tight turn over the beach before returning the net to its owners at RAF Brawdy.

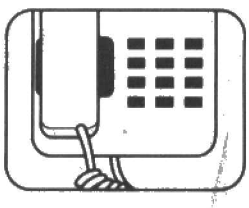
We remained on the island for another hour, filming seals and sea views before taking off again for Aberporth. It occurred to me then that perhaps the last people to have been on the island in such heavy weather were the hapless crew of the Hereford, the ship that foundered on the island in 1934 unintentionally bringing the rats that had such a disastrous effect on the island's ecology.

Representatives from Racal, the designers of the solid-state recorder used in the equipment, had come down from Southampton for the event and they joined us with the RAF flight crew for a drink in a private club in Cardigan, where we watched the HTV and BBC coverage.

Next month Andrew Armstrong will describe the operation of his amplifier and we will continue to cover the operation to save the shearwaters.



OPEN CHANNEL



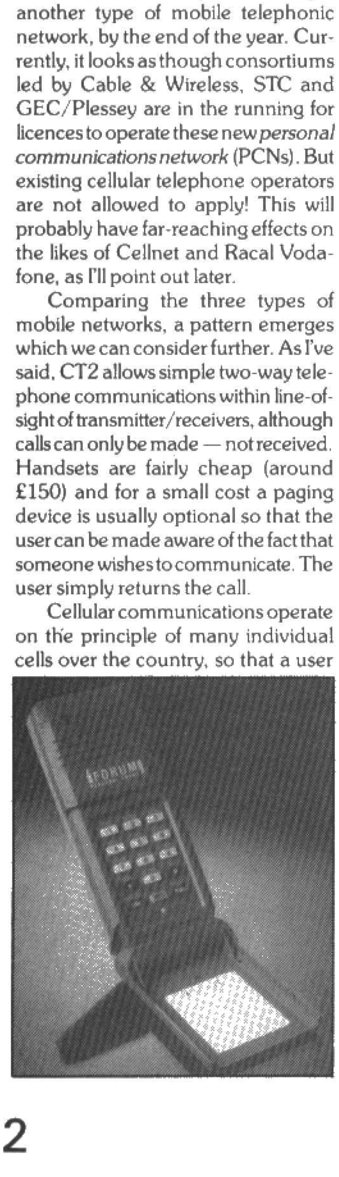
Networks are the topic of the day. Not so long ago, and in this very column, cordless telephones of the CT2 variety (second generation cordless phones, linked to the public switched network via transmitter/receivers positioned in public places) were described. If you're in any doubt, these hand-held pocket-sized phones are only capable of making a telephone call when they're within line-of-sight of these transmitter/receivers. They're also only capable of making a call — not receiving one.

As such, they're only a cheap alternative to a full cellular telephone network. Nevertheless, at around a quarter the outright cost of a cellular phone, and with much lower running costs, they would give many people the option of telephonic freedom at, perhaps, a more realistic price. CT2 networks, in many journals, have been given the collective name *telepoint*.

Now the whole CT2 possibility is in jeopardy. Our illustrious Government has recently announced plans to issue licences for three operators of yet another type of mobile telephonic network, by the end of the year. Currently, it looks as though consortiums led by Cable & Wireless, STC and GEC/Plessey are in the running for licences to operate these new *personal communications network* (PCNs). But existing cellular telephone operators are not allowed to apply! This will probably have far-reaching effects on the likes of Cellnet and Racal Vodafone, as I'll point out later.

Comparing the three types of mobile networks, a pattern emerges which we can consider further. As I've said, CT2 allows simple two-way telephone communications within line-of-sight of transmitter/receivers, although calls can only be made — not received. Handsets are fairly cheap (around £150) and for a small cost a paging device is usually optional so that the user can be made aware of the fact that someone wishes to communicate. The user simply returns the call.

Cellular communications operate on the principle of many individual cells over the country, so that a user within any particular cell can be connected to the public telephone network by the transmitter/receiver located in the cell. Roaming between cells during and between calls is made possible by the inclusion of complex switching exchanges located around the country. Handsets range from cheap and cheerful versions with few features (at around £100 or so — in my local town's free paper, one enterprising advertiser is offering handsets free to purchasers of satellite TV dishes and receivers — but beware the small print installation charge) up to pretty expensive beasts (£1000 or so) which make the tea when you ask for it. Running costs, however, are pretty steep. First, there is a rental of around £300 a year, plus the call charges (much dearer than conventional landline telephone call charges) on top.



PCN systems will be positioned somewhere between the two. They will be based on cellular technology (which is well proven) but will be much cheaper. The Government has left open the choice of standard until applications for licences have been received. One of two standards, GSM or DECT, will be used — both of which are digital cellular systems allowing pan-European operation. GSM is already well defined, while DECT probably won't be defined for a good few months yet, so it's more than likely that GSM will be chosen. Consequently, a choice of the GSM standard will mean that equipment could be available by 1992.

Now that we've compared the three networks we can look at the consequences of their existence. First, if PCN is cheap yet has much better characteristics and features than CT2, it's going to reduce CT2's potential. In effect, CT2 only has a year or so to get up and running, and to prove itself as a viable communications system with a large customer base. After this, the possibility of a much superior system just around the corner, and not that much more expensive, will prevent further customers from signing up — they will prefer to wait a few more months until PCN takes off.

Second, PCN will be of much lower cost than cellular telephone systems. This means that cellular costs must come down to compete. Cellular operators such as Racal Telecom have already begun to feel the pinch, with recent share price falls after the Government's announcement to issue PCN licences. The Government has also placed some severe technical restrictions on the cellular operators, designed to handicap their effective current monopoly until PCN operators can get their systems up and running.

The problem appears to be that a PCN communications system may damage irreparably both the communications networks it is designed to complement. The introduction of any PCN system must be closely monitored to ensure neither other network is harmed.

Virtually There

Although I've given details in the past regarding *centrex*, that is use of part of a single local or central exchange as a sort of private branch exchange, a further note of how the situation is progressing is worth taking. Users of centrex do not need a private branch exchange as the switchboard of a business — instead all telephones within the setup are connected directly to the local or central exchange, and are software controlled such that they act as if a private branch exchange is in force. Advantages are pretty obvious: the large initial outlay of the branch exchange on the premises is bypassed, the system is infinitely flexible, future options are all defined by software changes and so on.

The concept of centrex, however, is being taken to greater heights as network operators are looking on centrex to form the basis of private virtual networks (PVNs) — where a private network is setup between users on a national or international level. This incorporates more than one local exchange at as many business sites as the user desires.

As centrex really only works when digital telephone networks are in place, PVNs are currently just starting to be seen in the USA, but will be more in the news here as British Telecom's progress toward the integrated services digital network continues.

ITV Dilemma

Independent television looks as though it's about to be shaken up by the Government. Many suggestions, including the Government's own that each regional transmitting franchise should come up for grabs to the highest bidder and that the Independent Broadcasting Authority should be reorganised without any teeth, have been bandied about.

The independent television companies have got together and argued their case that they're doing a fine job as they stand, and that there's no need to change for change's sake. Underneath it all of course, their fear is one of lost revenue as advertising shifts from them to the satellite channels.

To this end, they've placed large (full-page) and expensive advertisements of their own in national newspapers and magazines, trying to create the impression that satellite television services cannot hope to compete with independent television quality. Main argument in these advertisements is one of programme cost. Figures have been quoted for hundreds of thousands of pounds to produce some independent television programmes, while figures of just a few thousand are stated for satellite equivalents. These figures are probably true — I've no reason to think otherwise and they haven't been strongly opposed by any of the satellite service providers — so what does this lead us to believe?

Firstly, are independent television programmes too expensive? Do we really want programmes the quality and lavishness of, say, Brideshead Revisited (one of the few quoted by the independents' advertisements)? If we do, can they not be made on a smaller budget? I'm not even going to attempt to answer these questions. It's sufficient, I believe, to consider an example in history when television programming was just starting. At the time, I'm convinced the Hollywood moguls and their ilk were feeling the same as the independent television companies are feeling now. After all how could movies, with their budgets of millions (in today's terms) expect to compete with television's budgets of tens of thousands. In the long run, of course, the higher budgets of movies have won through, and cinemas and the moguls themselves still make healthy profits.

Second, the independent television companies are merely trying to create a self-imposed smokescreen. They really need to stop whinging and just get on with it. Their higher programming costs can, I'm certain, be trimmed by a great deal without losing any programme quality or programme content. In the past there has been no similar competition (I'm discounting the BBC as its revenue is from licence fees rather than advertising) and so programming costs have largely been self-imposed. After all, if programmes cost more to produce, a simple increase in charges to advertisers will cover the difference. With many satellite channels (and many more other potential channels by microwave means, and so on) advertisers will be able to shop around to get the best deals.

But this doesn't mean that advertisers will move for the sake of getting cheaper air time, does it? Advertisers will place their adverts where they feel most people of the category they wish to target will watch. And good quality programmes and contents will ensure the independents can maintain a reasonable share of the viewers and so maintain a reasonable share of revenue.

By all means keep costs to a minimum — they'll be able to do that by simply not paying such inflated salaries to their overpaid staff — but above all, belt up and get on with it!

Keith Brindley

NEURAL NETWORKS

Mike Barwise put his brain under the microscope and examines the possibilities his cerebral machinations offer the world of computing

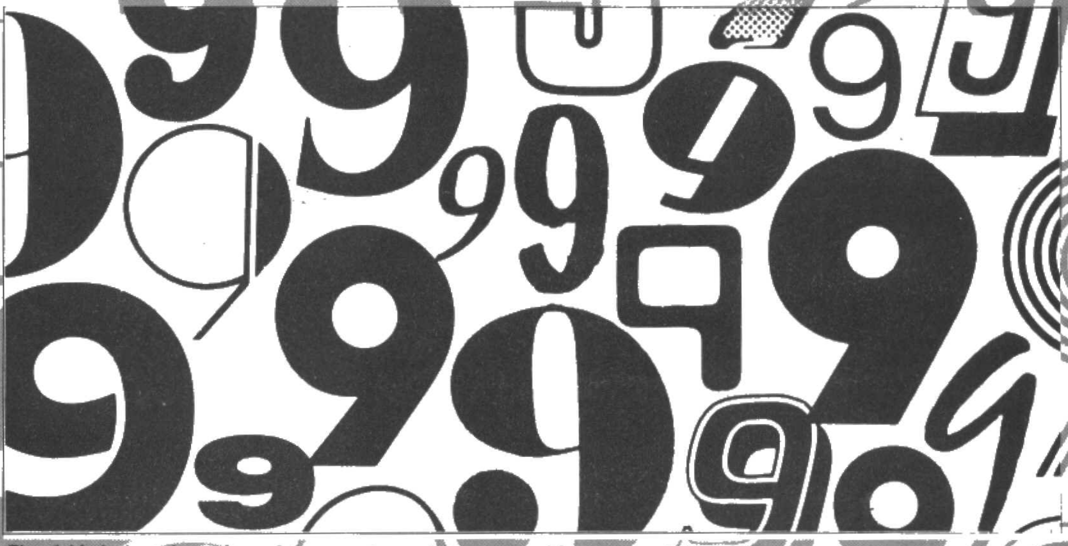


Fig. 1 Variations in style make computer pattern-recognition a complex task

Many tasks which are either very difficult or very time-consuming to carry out by hand can be performed easily and quickly by computer. This may seem an obvious statement but paradoxically the converse is also true. Many tasks which people carry out easily and quickly are very difficult to program on a computer and require vast amounts of computing power or time.

As an example, consider recognition of a human face. A face is not a simple shape to describe and differences between two individuals can be quite subtle. Nevertheless, a young child with no formal training is quickly able to recognise its mother's face. Not only that but this recognition isn't affected by distance (within reason), angle of view, lighting conditions, facial expressions, wearing of make-up, difference due to state of health or tiredness, portions of the face being masked by other objects (again within reason) and so on.

As an extension to this, once the child has learned to recognise a smile on its mother's face, the rules learned can be extended to faces seen for the first time. These concepts are all extremely difficult to describe algorithmically the first step to writing a computer program.

To bring the problem into sharper focus, consider the recognition of a much simpler shape, the figure nine. All the shapes shown in Fig. 1 are figure nines. They are all different shapes, sizes and orientations yet few people would have any difficulty at all in recognising them as nines. But if we ask people to put into words how they recognise them (let alone write a formal algorithm) or to explain what that essential property of 'nine-ness' actually is, then very few would be able to give a coherent answer.

Both cases we have considered are examples of recognition, just one of the classes of problems generally lumped together as AI (artificial intelligence), in which research with conventional computers is proving so difficult.

Since the human brain is so good at doing some things which a computer is so bad at, a growing band of AI researchers have been turning their attention away from trying to program conventional (von Neumann architecture) computers in which instructions are executed sequentially. Instead they have turned to how the human brain works.

The Human Brain

The human brain is made up of neurons, a rather stylised representation of such being presented as Fig. 2. The hub of the neuron is the soma, the inputs are the dendrites and the axon is the output. Where an axon connects to a dendrite of another neuron, the connection is called a synapse.

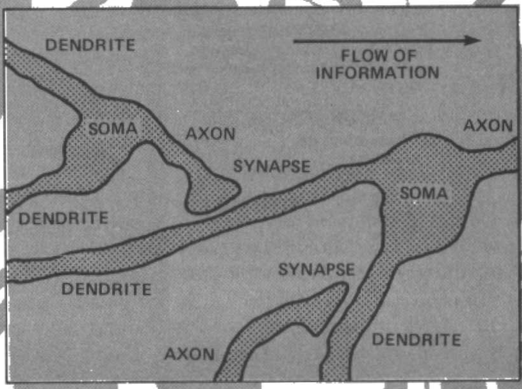


Fig. 2 Neurons in the brain

Neurons are the processing elements of the brain. Their basic functionality is shown symbolically in Fig. 3. In essence, all each neuron does is sum the values of its inputs, applying a weighting factor to each, and give an output if this sum of weighted inputs reaches a pre-set threshold. Inputs may be either excitatory or inhibitory. (In other words the weighting factors may be positive or negative).

Compared to a computer processor of the type we are used to, this is an extremely simple computing element and it seems incredible that this could give rise to the processing power of the human brain. The secret is not in the power of the individual neurons but in the vast numbers of them and the interconnections. It is estimated that a human brain has about ten billion neurons and two to three thousand billion interconnections.

Neural Networks

From what we have seen, it is fairly clear that it would not be a very difficult task to build an electronic version of a very small portion of a brain. Such a circuit could be represented as shown in Fig. 4. The numbers on

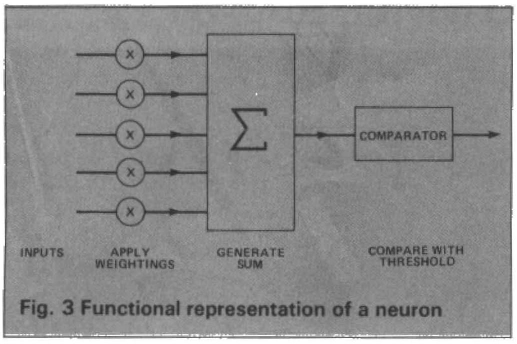


Fig. 3 Functional representation of a neuron

the interconnecting lines represent the weighting factors and the numbers within the nodes represent the threshold. Clearly the nodes are analogies of neurons and such circuits are generally referred to as neural networks.

At this point it would be useful to take a simple example to show how such a network could carry out a task. Let's assume that we intend to build a domestic robot, the duties of which are to feed the household pets — namely a cat, a dog and a rabbit. The robot is able to detect whether the animal is wearing a collar (either the cat or the dog), whether it has long ears (either the dog or the rabbit) and whether it is white (the cat or the rabbit). The cat is to be given fish and milk, the dog a bone and water and the rabbit lettuce and water.

A neural network of the form shown in Fig. 5 would be able to solve this problem. It can be seen that the neurons are arranged in two layers, an input layer and an output layer. Every member of one layer is connected to every member of the other.

In actual fact this type of network is rarely used as it has been proved mathematically that it is not able to evaluate the XOR (exclusive OR) function, eliminating a large number of potential applications. Instead, at least one hidden layer of neurons is added between the input and output layers and the XOR limitation is overcome.

The domestic pet feeder problem is re-worked as a three layer network in Fig. 6. In both Figures 5 and 6 the thicker lines indicate excitatory connections and the thinner lines are inhibitory. In such a case the various weightings could be worked out without too much difficulty but this is a trivially simple example of a problem which could easily be worked out using a conventional computer. In the general case the number of neurons and interconnections would be too great to program the network by working out and applying weighting factors. Instead a network requires to be 'taught' using a process of trial and error.

Learning By Experience

In order to be able to teach a neural network, the circuitry needs to allow the weightings of the interconnections to be changed interactively. This is the basis of an adaptable neural network, one which is able to learn from experience, another of those goals much sought after in the realm of AI.

A neural network does not learn by itself, it requires a teacher which could be a person or more likely a conventional computer. An un-programmed network will start life with all the weightings set to random low values.

To start teaching it, the first pattern is applied to the inputs and the outputs compared with the required output. The difference between the actual and the target outputs is used to work out which weightings require modification. The required interconnection weightings are modified by a small amount and the process repeated. This continues, perhaps hundreds or thousands of times, until the output converges on that required. (If an attempt was made to effect too rapid a convergence, the outputs would oscillate about the required result with each pass.)

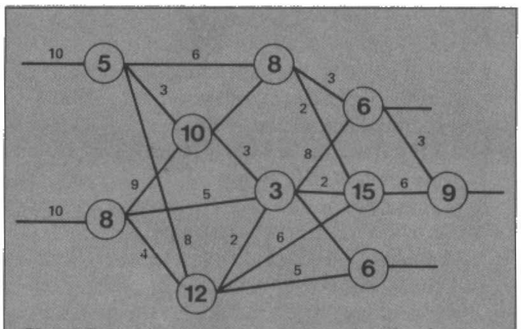


Fig. 4 Functional representation of a simple neural network

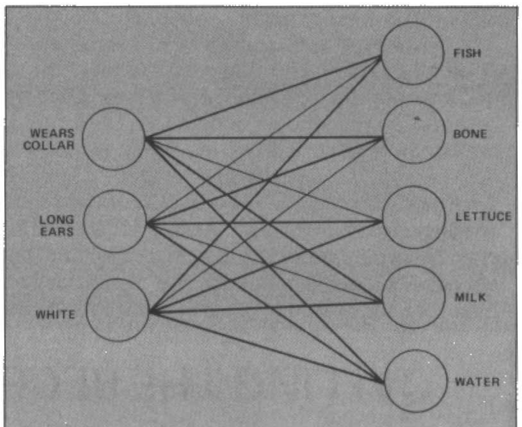


Fig. 5 Example of a simple 2-layer network

Having taught the network to recognise one combination of inputs the teaching continues with subsequent input combinations until the network is able to recognise all required combinations. If we consider that the inputs could correspond to whether or not a pixel of a rasterised image is illuminated, then we start to see the scope for image processing, character recognition and so on.

Properties Of Neural Networks

In the example of the domestic robot, the three layer network had the concept of cat, dog and rabbit represented by a single neuron each. In all but the simplest of cases this would not be so and a typical network of a few hundred nodes would have any

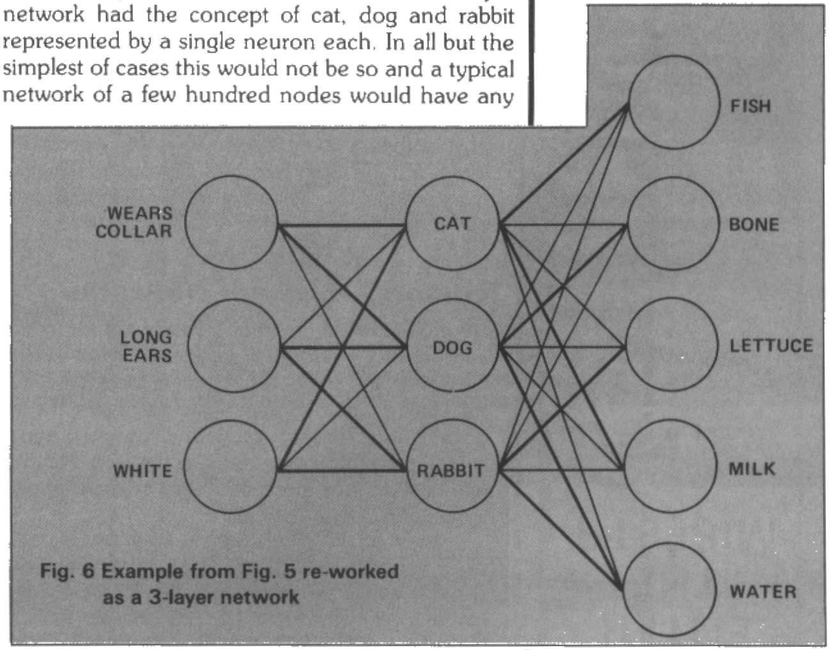


Fig. 6 Example from Fig. 5 re-worked as a 3-layer network

particular concept represented by a particular combination of nodes being active. There are a number of important implications of this, many of which are common to the human brain.

One implication of this so-called distributed memory is automatic generalisation. As an example, assume that nodes 7, 8, 15, 21 and 34 when simultaneously active represent 'shoe'. The likely representation of a closely related object such as 'boot', would certainly be similar — say 7, 8, 15, 21 and 48. Now if the network has been taught that shoes are worn on the feet, it is highly likely that the network would 'assume' that boots are worn on the feet even though it had never been specifically taught this fact.

Immunity to damage is another result of distributed memory, one which makes neural networks of significant interest to the military. In a conventional computer, any damage to a small portion of the circuitry is often catastrophic — the whole thing just ceases to operate. Damage to a small part of the memory might not be fatal but certainly some portion of data would be lost completely.

Not so in a neural network. A result of the fact that a particular concept or item is represented by a potentially large number of neurons is that damage to a small number is likely to slightly degrade the 'understanding of various items rather than obliterate it. This is certainly consistent with the observed results of aging on the human brain. As people get older they often find it progressively harder to recall information, but never suddenly announce that they have never heard of a car, or cannot grasp the concept of Friday.

Another aspect of distributed memory is the neural network's ability to cope with partial data, currupted data and slightly different variants of the same data (such as the figure nines discussed earlier). Such are the number of nodes representing say the figure nine, that quite a number could be missing or misplaced (or extra ones present) without the network failing to recognise it. Once again this is consistent with the operation of the brain. As an example of the versatility this offers, Fig. 7 shows a well known face in detail and in outline. The human brain still recognises both versions of this picture — a neural network could do the same.

A neural network can be considered a parallel processing computer taken to the extreme. To those familiar with parallel processing (using perhaps the Inmos Transputer), the implications of this will be obvious. A neural network can operate very quickly. In addition the time taken to come up with a result does not depend on the complexity of the task. For a given network the time taken for signals to propagate from the input to the output will always be the same. The human brain with response times in the region of 0.1s (being essentially chemical in operation) is much quicker than standard computers for pattern recognition. The potential of an electronic neural network is really something to speculate on.

History Of Neural Networks

Neural networks, parallel distributed processors, connectionist machines - call then what you will. Despite all the hype about them in today's AI circles, they are not new. Research into simulating the brain goes right back to the start of the computer age and it was probably only because the von Neumann architecture 'got there first' that interest in neural research faded somewhat.

Even so, the 1950s still saw a significant amount of effort put into neural networks. Invented by Frank Roseblatt, the *Perceptron* was a two layer network for classifying input patterns. Ironically, despite its success in the purpose for which it was designed, it served to put neural research into the doldrums for a couple of decades as it was the vehicle used by Minsky and Papert to show that such networks had the inherent XOR limitation mentioned earlier. Unfortunately the fact that the inclusion of a hidden layer overcomes this problem did little to alleviate the effect of this downturn in interest. Neural networks have only emerged in a big way again in the last three years or so as it became more and more obvious that the von Neumann architecture did not, after all, provide the universal panacea.

Real Products

So exactly who is doing what with neural networks and what does the future hold? Surprisingly, only quite modest networks have ever been built. However, this is about to change, as a number of companies including Fujitsu, Cal Tech and Synaptis (a new company specialising in neural technology set up by Dr Federico Faggin, the founder of Zilog and inventor of the Z80) have announced plans for neurochips.

Ironically, the lack of networking hardware has meant that most research work on this topic has used software emulations of neural networks running on von Neumann computers! This doesn't place in doubt the future of neural architecture however. Although such simulation is possible, it is carried out sequentially which for an array of a few thousand nodes would keep even a Cray busy for quite a while!

So just what has been achieved so far? The following is a selection of applications which have come *off* the drawing board:

Fujitsu has built an experimental robot driven by the outputs of a neural network, the inputs connecting to various sensors. This robot is able to adjust to its surroundings and is expected to form the basis for developing a flexible real-time controller for use with industrial assembly robots. The intention is for these to adapt to their surroundings and hence not have to be programmed with a specific sequence of events.

Nestor, one of the old timers with 13 years in this up and coming industry, has a number of products. Of particular interest is one aimed at Japanese text entry, a severe problem with a language of over 30,000 characters (imagine trying to find a character on a keyboard eight feet square!). The Nestor system allows handwritten input to be read and passed along to a PC. Other systems for recognition of handwritten text are available. On a quite different tack, Nestor has a system to predict trends in the securities market.

NEtalk, developed at Princeton University, reads plain English text and drives a phoneme speech chip giving a spoken language output. Certainly this has been done on a conventional computer but at the expense of a considerable degree of programming effort. Apparently NEtalk was trained in about a day, having initially produced streams of gibberish.

Wizard, designed at Brunel University, takes signals from a TV camera as its input and carries out complex image analysis. It has been demonstrated on a trivial yet impressive task of learning about expressions on human faces and subsequently being able to indicate whether a face is smiling or frowning. More practical applications are optical character recognition and analysis of medical imaging.

Conclusion

I suppose we shouldn't call this a conclusion since the whole article is just an introduction to this embryonic technology. Three years ago we introduced the ETI readership to an area of computer technology which had barely left the research laboratories — namely the

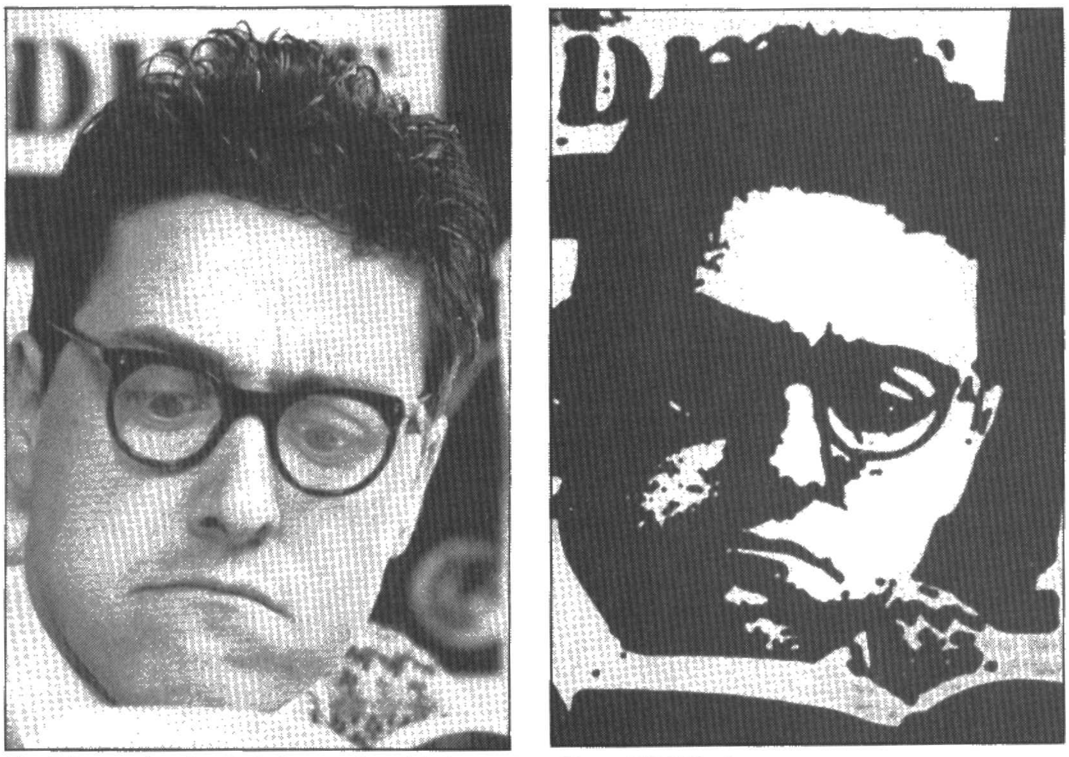


Fig. 7 Decreasing detail of a human face (photo courtesy Thorn EMI Video)

RISC processor. At that time we concluded by posing a hypothetical question - whether RISC technology would indeed shape the future or whether it would be destined to just a place in the history books like bubble memories. Far from being committed to obscurity, we have seen the Acorn Archimedes being based on the ARM RISC processor and, in the last year, RISC offerings being launched by major semiconductor manufacturers.

We could say that neural networks take the concept of RISC and parallel processing to their ultimate conclusion. Let's hope that their future is equally assured — I for one can't wait to get my hands on them!

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THE VFM TOTAL KIT

Wilmslow Audio's new VFM speaker kit is remarkable VALUE FOR MONEY! The design uses an Audax bass unit and a Peerless dome tweeter integrated by a multi-element crossover and gives excellent results for it's modest cost.
The kit contains all the cabinet components (accurately machined from smooth MDF for easy assembly), speaker drive units, assembled crossovers, grille foam, wadding, binding post connectors, screws, assembly instructions, etc.

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ROCK CIRCUS

Geoff Martin waxes lyrical at the star-studded premiere of London's newest attraction — audio animatronics' finest hour

Ever wanted to return to the good old days of rock and roll? Ever longed to relive those hours of ill-spent youth at that classic live concert? Well you're in luck. A new permanent exhibition has opened in the heart of London — a show of animated and static rock star idols performing their greatest hits. The Rock Circus has come to town!

Rock Circus is housed in the top floors of the Pavilion, the new shopping centre off Piccadilly Circus. There you can see and hear how your music heroes established themselves as part of our music culture in an entertaining and appealing presentation. Some might even call it revolutionary, for what you will see and hear cannot be experienced in public anywhere else in the world.

Upstairs the show comprises a display of life-size robots mimicking the motions and mannerisms of their human counterparts from the pop music world. Plenty of other stars appear downstairs but unfortunately they have not been granted the privilege of articulation.

The Tussauds group, famous for its wax figures, conceived the idea about three years ago when the company was looking to launch a new entertainment in London. Market research found rock music to have the greatest potential as a popular theme.

Madame Tussauds is well known for static displays of famous (and even infamous) characters past and present both at its London base where we are told "the wax really works", and at other display sites such as Windsor Castle. But to present a permanent display of 'stiffs' in what is a very vibrant and dynamic section of our culture was a bit of a non-starter to say the least. So the only option open to them was to get those dummies moving. How could it be achieved?

It so happens that a Walt Disney production team in the States was the first to produce robots in human form but it has been the Tussauds group that developed the idea further, particularly in the area of moving limbs and facial expressions. But there is a price to be paid for all this angulation. The huge number of mechanical parts installed into the body of the robot makes it impossible to fit in a power source and control centre. The 'animatronic' therefore does not have the means to move independently, and all movement is controlled externally. You can see this in the picture of the 'fab four'. No chance of Ringo going walkabout here!

Not wishing to be imitated, Madame Tussauds patented their developments, trademarking them under the term audio animatronics. The skill of the group in producing life-like figures coupled with their animation techniques gives them a world lead and a unique exhibition. So at a cost of £10 million and 50 figures of the biggest names in rock history later, the show has got underway.

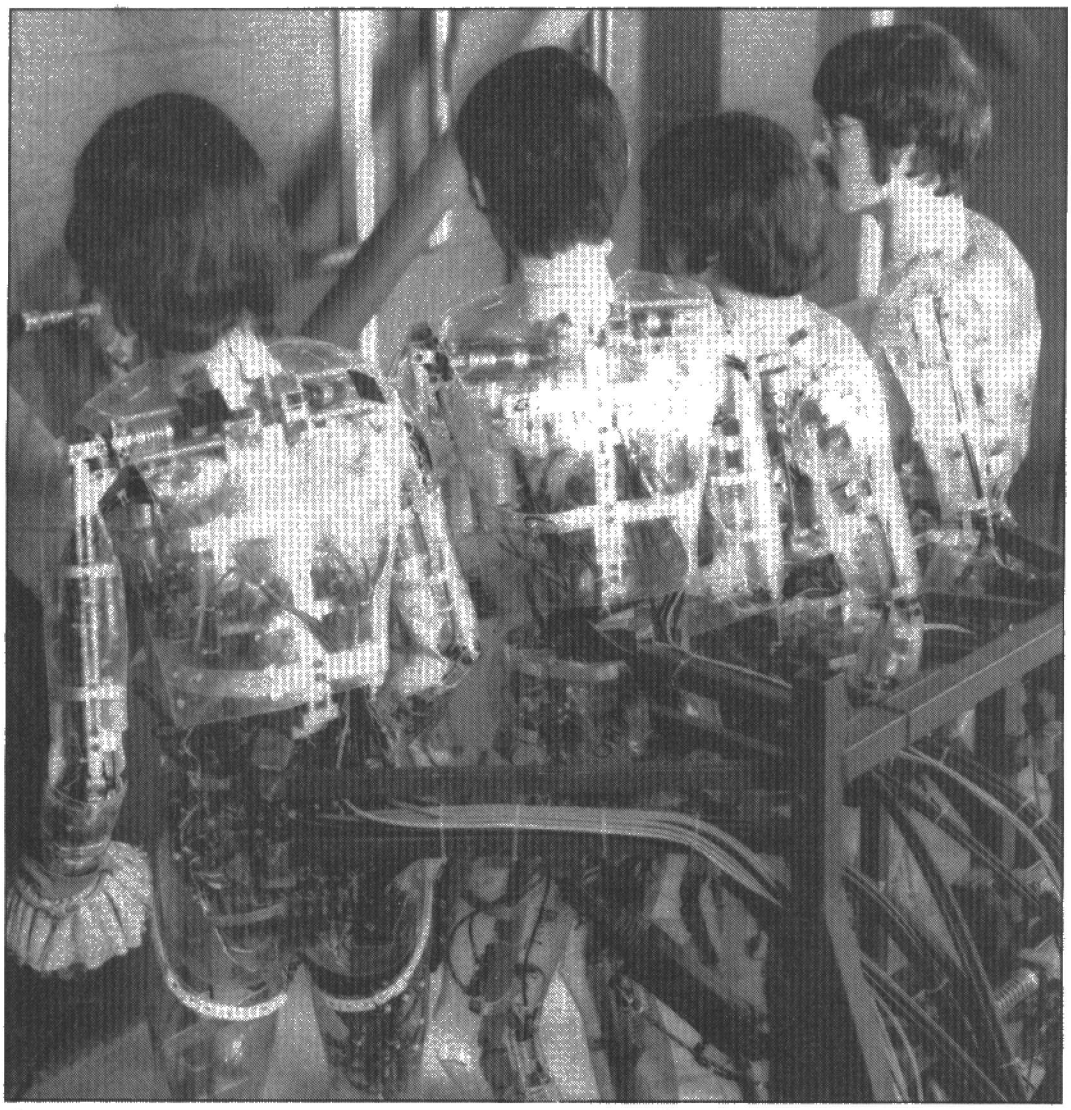
Pick Of The Pops

Just who should make it into this immortal rock show was a painful and lengthy decision process but the choice was left to Paul Gambaccini, an acknowledged authority on the history of rock and pop. Just some of the names include: Elvis, Elton, Stevie Wonder, Little Richard, The Who, The Stones and of course The Beatles. The fab four are in fact deemed important enough to appear twice — first as 'stiffs' in Cavern gear, then as robots in 1967 garb. But we digress, so back to the storyline.

To achieve co-ordination over such a complex array of moving figures, sound, lights and effects has taken two powerful computers and a considerable amount of time to work out. One computer controls the animatronic figures and sound, while the other takes care of the lighting, stage movements and effects. The biggest problem for the engineers was to program the robotic movements into the computer so they would synchronise accurately with the music. The process has taken about a year.

When the final selections of the 'greatest rock music of all time' had been made, the recordings and introductions were mixed down onto laser disc. Many compact discs were compiled especially for the show along with a 12-inch master. Tim Rice (your robotic compere throughout the finale) wrote and voiced the scripts for the animatronic section of the show in an uncharacteristically punchy style. To help co-ordinate all the actions, a time-coded track was also recorded onto the master 12-inch laser disc. This sequence of pulses instructs both computers to operate and arrange everything else at the right time.

Every action from limb movements to stage rotations and video effects is blown into EPROM. Each animatronic stage set has its own EPROM to give the system the flexibility of being updated at any time, should extra characters be introduced. With this in mind, there is a space called the 'hot spot' where the next giant of rock will stand — voted for by the punters.



Four-sprung durch technik — the prefab four operating with a little help from their tubes

Blowing In The Wind

The heart of the robotic action depends upon converting electronic control signals into movement. This movement is achieved in two ways. Firstly a servo pneumatic system is used to give varied speed and proportional movements. These are used for main limb actions and also where slower, more delicate movements are called for. The incoming digital signals are converted to analogue voltages which then operate servocylinders. The change in air volume and pressure, proportional to the analogue voltage, moves a piston and so movement occurs.

Secondly, pneumatic switches are adopted in actions where quick changes are demanded. This happens in sudden arm or eyelid movements. Here the signals maintain their digital form and operate solenoid valves which open and close the air flow to the cylinders.

All movements are powered by compressed air working at 850kPa pressure (don't panic — that's 120psi for old timers). As so many facial and limb movements are required, there is no shortage of plastic pipelines leading in and out of the bodies (see back view of the Beatles photo)!

The Sound Of Silence

One major new feature of the show is that all the exhibits take place in complete silence. You explore the music of Rock Circus totally in the privacy of your own head by using cordless headphones. Everyone who enters the show gets a pair of these to put on. It creates a strange situation - never before will you have seen so many people walking around wearing sonic earmuffs. Sometimes it gets difficult to know who is real and who is not.

The way the cans work is not a new concept as the idea has been around since the invention of remote controlled TV. It's all done with infra-red beams. Digital stereo audio (from compact disc) frequency modulates an infra-red beam. It is transmitted in a cone from above, just as a downlighter would with light. This method of transmission creates a tight radiation pattern to reduce co-channel interference from the next music maker. So as you walk around, the sound automatically switches from zone to zone. Clever huh!

The headphones detect the infra-red beam and the signal is demodulated to restore the audio. Hi-Fi stereo is then amplified and delivered to your ears in the normal way. Happily you do have a volume control to suit your listening requirements, be it mind-blowing or otherwise. It's a good audio system (hi-fi but not super-fi), and is ideal in this situation. When you've finished with them for the day, the headsets are returned to be recharged overnight ready for the next punter, complete with sterile padcovers.

To overcome the problem of a stage set change, a mountain-will-go-to-Mohammed technique was adopted. Put three stage sets around in a circle and rotate your audience on a revolving theatre in the

WIN!

We have six pairs of Rock Circus tickets to give away. See page 66 for details.

centre — brilliant! That way you get three audiences on the move at any one time. A good idea which also serves to get maximum audience throughput.

In summing up I would award full marks to the Tussauds Group for accuracy in the features and appearance of the models (except Cliff Richard), no surprise as they have had so many years in this field. However, I did expect the animatronic figures to be a little less robotic in their movements. Knowing the time it took to program in those movements, and cramming the mechanics into such small spaces, it could take forever to develop what appear to be natural actions.

Having said that, the highlight for me was to see the movements of 'Phil Collins' playing his (or should I say its) drum set with the drumsticks that the real Phil donated. This lasting memory perhaps is due to the accompanying effects such as the drums appearing from the stage below just in time for the drum break of 'In The Air Tonight', and the pencil beam laser light piercing the smoke and reflecting from the drum kit in what appeared to be every direction (one assumes that not to be the case as the engineers must have arranged the reflections very carefully to avoid direct eye contact).

Other highlights include Bobby Dylan giving us a rendering of 'Times They Are A Changing' whilst playing guitar and harmonica. It was a treat to see realistic fretwork with his pneumatic left hand (air on a G-string, one might say). Also Madonna with her animated tiger whose eyes lit up on hearing some of her dulcet tones and on to mixed film shots of the space shuttle take-off with David Bowie 'floating round his tin can'. Finally the Beatles bring the show to a close in full Sergeant Pepper regalia, and supported by an updated set of cardboard cut-outs to complete the album cover recreation. This must be a show where, in their words — 'a splendid time is guaranteed for all'.

Rock Circus is situated in the London Pavilion, Piccadilly Circus. It is open from 10am to 10pm every day except Christmas Day. Prices are £4.20 for adults, £3.15 for children.

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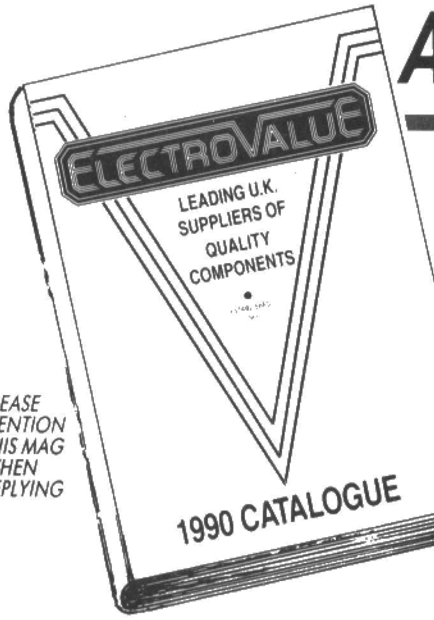
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TESTING TESTING

Mike Barwise compares analogue meters with their digital counterparts in the second installment of this test gear series

In our look at the theory and practice of using test gear, we have got as far as the moving iron meter which, as we said at the end of last month, is rather crude. It is much less linear than moving coil meters and remarkably insensitive. In order to improve measurement at low AC signal levels, the *valve voltmeter* was invented.

The valve voltmeter is basically a moving coil meter preceded by a very linear amplifier and a compensated full wave rectifier. It was *valve* because that was the technology of its era, but an equivalent modern technology circuit is shown in Fig. 1.

The first stage amplifier has a flat response over a wide bandwidth, a range of extremely precisely set gains and a very low noise coefficient. This feeds the second stage amplifier, which has unity gain but is an operational or differential amplifier fitted with a pair of back-to-back diodes in its feedback loop. The output of this active rectifier is buffered by a third unity-gain amplifier, feeding the meter movement. This is shown in voltmeter configuration but there is no reason why alternative modes of operation could not work as well.

OK I hear you ask, why so complex — why not just use an amplifier and a bridge rectifier brick? The answer lies in the diode forward threshold voltage. There is with any diode, just like with the LED we discussed last month, a minimum voltage which will cause it to conduct in the forward direction. If the output of a (theoretically) perfect full-wave rectifier is plotted it will look appear as Fig. 2. Our real component, however, fails to conduct if the input voltage lies between say, −0.5V and +0.5V, so its output will look like Fig. 3. When you come to smooth (integrate) this waveform, with a capacitor for example, the resulting charge on the capacitor will be a bit less than it should be (if the rectifier was perfect). This becomes obvious when you consider that you are in fact assessing the area under the curve.

What the op-amp does is almost eliminate the loss of area under the curve. Consider the sequence of operation: while the input voltage is above the diode forward threshold Vt, the relevant diode (depending on the input polarity) is in conduction and the op-amp/diode brick acts just like a conventional rectifier, as the op-amp has unity gain. However, when the input voltage is below the diode Vt, the diode stops conducting. There is now no negative feedback round the op-amp, so its gain suddenly goes from unity to infinite. Infinite gain means that for no change at the input, the output swings hard to rail (of course our gain is not actually infinite; we need *some* change at the input but very little). Now, the output of the op-amp is rapidly moving towards say ±15V, but the output is fed back via the diodes to the input, so as soon as it reaches Vt... Well, blow me down! The diode is conducting again!

What we have effectively done is to smarten up the transition from −V to +V. There is a little waveform distortion by virtue of an increased gradient over this region (Fig.4). Although it is common mode to both half waves, affecting both in the same manner (it adds a bit of area to both) and therefore represents an irreducible error, the result is much more precise that obtained by the passive rectifier. This is increasingly true as the AC swing approaches 2Vt. Below an AC swing of 2Vt, the passive rectifier will not work at all whereas, with suitably low-noise diodes, the active rectifier can deliver excellent results at AC RMS in the region of 1-10mV.

It is important when choosing or designing a suitable op-amp for an active rectifier like this to go for a high open loop gain and a very fast settling time (the time taken for the output to stabilise at unity gain after an infinitely fast 10V step at the input, and a measure of the square wave distortion of the amplifier).

You should, however, try to avoid a high slew rate. This is the rate at which the output is capable of changing, but is measured according to rather different criteria and is normally expressed in V/microsec. Commercially available op-amps vary in slew rate from about 2V/microsec to 16000V/microsec. It is a common mistake to consider that settling time and slew rate vary in proportion, to yield a 'fast' op-amp or a slow one. For example, two Harris 'high-speed' op-amps, each excellent for their own applications, are the HA-2539 (slew rate 600V/µsec. settling time 200ns) and HA-2541 (slew rate 300V/µsec. settling time 80ns). Both have an open loop gain in excess of 25000 but the 2539 requires a gain of 10 or greater for stable operation, whereas the 2541 is happy at unity gain. I think it is obvious which of the two is more suited to the active rectifier (yes that's right, the 2541).

With these quite modestly priced components, I have performed active rectification at up to 5MHz, with a resolution of about 1% down to a few mV.

The problem which results from a high slew rate is overshoot. You should remember that the diode in our active rectifier does not turn on instantly. There is a brief period (dictated by such factors as junction capacitance and measured in nanoseconds) between the application of Vt and the diode starting to conduct. During this period, the op-amp is still working at open loop gain so its output is still shooting towards the relevant rail. By the time the loop is closed by diode conduction, the op-amp output voltage is in excess of Vt in proportion to the slew rate divided by the diode turn-on time.

This results in an output waveform similar to Fig.5. The spurious bump adds area under the curve, thus distorting your results. You will never totally eliminate this effect and it is the limiting factor on the operating frequency of an active rectifier. When the diode turn-on time t_d (Fig.5) becomes significant compared with the half-period of the AC you are rectifying, the size of the bump begins to matter. The rectifier will totally fail when the signal half-period equals $2t_d$ (on the assumption that the diode turns off at about the same speed). Suitable choice of fast diode and low slew-rate plus fast settling op-amp minimise the introduced error.

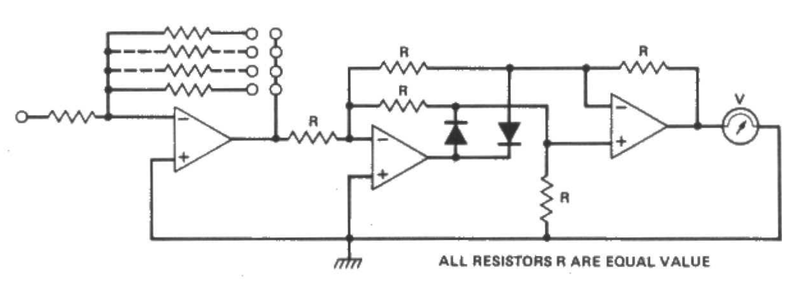

Fig. 1 Valve voltmeter equivalent circuit

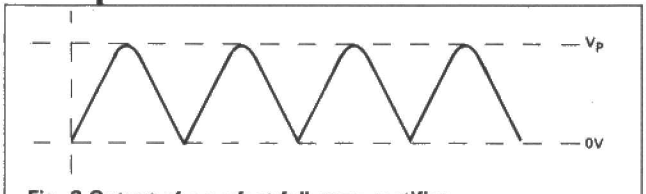

Fig. 2 Output of a perfect full-wave rectifier

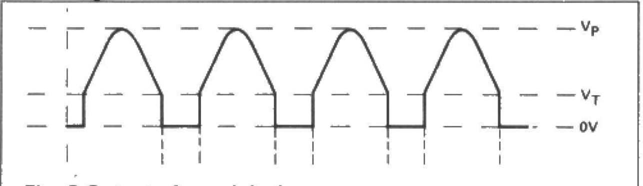

Fig. 3 Output of a real device

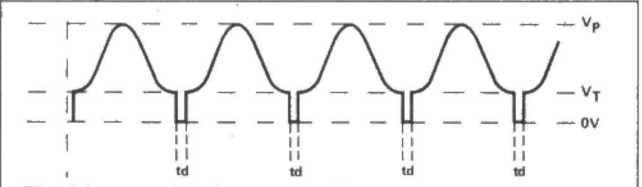

Fig. 4 Improved performance with smoother transition points

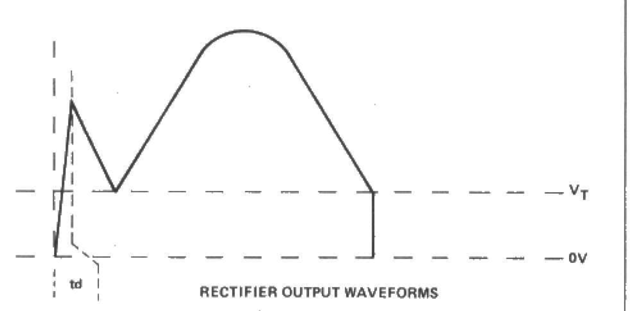

Fig. 5 Output problems with high slew rate

Returning briefly to Fig.1, the mechanism of the full wave rectifier is worthy of description. In addition to the two diodes in the active rectifier feedback loop, resistors are needed in practice to isolate the outputs from the inverting input. This circuit is really a phase splitter. It has two outputs, one passing positive going half-cycles and the other the negative ones. Each of these outputs corresponds to that of a half-wave rectifier and the two are combined by the buffer op-amp (acting as a summing amplifier) to provide a full wave rectified result. If you follow the circuit through, you will see that positive going half-cycles are applied to the buffer amp in non-inverting mode, and negative half-cycles in inverting mode. Inverted negative equals positive, so problem solved! The buffer amp input not used on any half-cycle is connected to the virtual earth at the rectifier amp inverting input via the relevant feedback resistor.

The Digital Alternative

Digital meters (to date) all work on the same principle — an analogue to digital converter drives a digital display. The crucial difference between digital and analogue meters is that the A to D measures *voltage* whereas the analogue (electromagnetic) meter measures *current*. It is possible to achieve input resistances in excess of 20M using modern MOS components, so the question of loadings on systems under test really does not arise (unless you are testing MOS circuits!).

The A to D is normally preceded by a network of passive (and sometimes active) components to allow range and function switching.

Until now, the normal choice of A to D converter has been the *dual slope* A to D. These are capable of extremely high resolution but are very slow. The device works in two operational phases. First a precision capacitor is charged by the incoming voltage. Secondly the capacitor is discharged at a constant current, while a counter runs. When the charge on the capacitor reaches a critical voltage, the counter is stopped and the counter output represents the input voltage. It is possible to resolve to five decimal digits (1 part in 10^5 or 0.001%) but it does take its time: three readings per second is about average.

It will be interesting to see what happens now that high resolution flash A to D converters are appearing: the update rate problem may become a thing of the past.

Analogue vs Digital

Let us now put the analogue (moving coil) meter in the ring against digital (A to D) meter. (Ten rounds or a knockout). What are the pros and cons of each in use.

Age before beauty so let's look at the analogue first. The most important point about these (including the valve voltmeter) is that they read continuously. Given a good quality meter movement, an analogue meter will indicate transient events and will also be much quicker to use in the hands of an experienced engineer. The human brain finds it easier to quickly absorb spatial information (needle about halfway across the scale) than to absorb numeric information, which needs mental processing by the logical/sequential hemisphere before it means much.

The reading resolution will suffer (most analogue meter movements resolve to about +1%) but there are many occasions where any more resolution than this is either superfluous or spurious due to the reliability of the equipment under test. A good TV or radio engineer can probe about your duff gear with an AVO8 or similar at high speed and come up with a fault diagnosis quicker than you could connect up a digital testbed, just by watching the needle and knowing what to expect.

That is the crux of the matter. If you are examining the totally unknown, the analogue meter may well not have the resolution to provide valid answers, especially in modern research, where the activities of Thursday Afternoon Particles are pretty imperceptible anyway.

The other area in which the basic analogue meter can let you down is when you are looking at high impedance circuits. 20kΩ (50μA) seems fine until you examine CMOS which draws less than 1μ at its inputs. It should also be considered that the meter exhibits a small inductance (there is a coil in it!) and the effect of this on the circuit under test should be taken into account. The basic analogue meter is thus best at examining conditions which are expected to change relatively slowly or are expected to be stable. It is excellent at demonstrating when such signals are not as expected.

Now for the digital meters. Theoretically there is no limit to the resolution of the dual slope A to D used in a DVM. In practice, few DVMs read beyond 6½ digits — it is likely that more resolution would exceed the accuracy of the best gear you could build. So, full marks for detailed results.

However, a rate of three to five readings per second almost guarantees to miss important short events so that instead of just the AVO 8, you now need a DVM and an oscilloscope for even basic testing. Input impedances are generally in the region of 20M, so for normal work loading of the circuit under test can be ignored. You will still have to take precautions you take measurements around small signal FETs and CMOS.

DVMs, AC And Other Features

It should be considered when using the average DVM (say up to £300 and 3½ digits) that the AC ranges are normally calibrated for frequencies up to about 1kHz and errors will begin to creep in beyond this limit as the active rectifier will be running out of bandwidth. It is possible to obtain demodulator probes for DVMs, which allow working from about 1kHz to beyond 1MHz but their accuracy is much lower than the meter could deliver within its working range.

It also becomes important to consider the effects of probe capacitance when taking measurements at high frequencies. If you apply any probe to a tuned circuit (Fig.6), you effectively add a capacitor to ground. This will tend to lower the resonant frequency of the circuit under test in proportion to the significance of the probe capacitance. Thus if the probe has a capacitance of 20pF, the tuned circuit capacitor must be 20nF or greater to meet our non-invasion criterion of 10^{-3} (see last month). Tuned circuits with smaller capacitance will be proportionally lowered in operating frequency which, for a given amplitude, will transfer less energy. So once again a high measured voltage will be lower than actual, even when using a high impedance probe (so as not to drain power from the circuit). It is not possible to eliminate this phenomenon but it can be compensated — I will show you how later on.

Many modern DVMs come with special extra features. These include high current ranges (up to 10A), capacitance-measuring ranges and diode and transistor test functions. A quick look at the technical specification (with the help of a Japanese dictionary) will normally show that these features come nowhere near the basic ranges in terms of accuracy or precision even though their resolution is the same. They are useful extras for quick checking of components but in no way replace the specialist instruments for selection purposes. Their main use is in fault finding and repair work but they cannot be relied on when you are designing things like amplifier output stages and want supermatched transistors, or where you are selecting any other components to tight tolerance. Unfortunately, the specialist gear capable of this kind of testing costs a fortune.

To sum up then, voltage probes with little lights and multimeters all have their main application in testing static or slowly changing conditions. With due regard for meter input characteristics, very high resolution may be obtained under static signal conditions using digital meters (DVMs), but analogue meters are much better at indicating transients (in skilled hands) and are quicker to read. They do, however, suffer from generally worse input characteristics and lower resolution.

A major advance in analogue meters is the amplifier meter valve voltmeter, which renders the input characteristics similar to those of the DVM and can improve resolution and range by a couple of orders. In most cases, the meter probes (test prods, bits of wire) do not contribute significantly to artefact when using meters. If they do, the meter is probably the wrong tool for the job. However, as with all other gear to be discussed, you must ensure that the meter applies an insignificant load to the circuit under test. If something changes (say an oscillator stops) when you apply the test prods, think again. Maybe you need some other gear, such as an oscilloscope.

If so, you had better place your order for next month's ETI and the third installment of this test gear series.

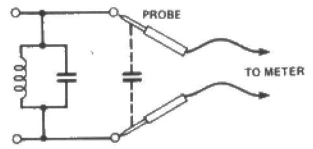

Fig. 6 Applying a probe to a tuned circuit

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UNDER SURVEILLANCE

CIRCUITS

3: Towing The Line

Paul Chappell continues our surveillance series and turns to the telephone system

A favourite target for any snooper, whether 'official' (police, government agencies and so on) or freelance, is the telephone. Not only is it a concentrated channel of information, with a high gen-to-chat ratio, but it also avoids many of the problems associated with room bugs. One of the golden rules for using any kind of bugging device is to get the microphone as close as possible to the mouth of the buggee. Some commercial devices may claim to pick up a whisper at twenty feet. Who knows, in a soundproof room with a very loud whisper they might just make it. Whether you can actually make out what the whisperer is saying is another matter altogether. With a telephone, the information provider is thoughtful enough to speak directly into the microphone. What could be better?

Then there's the matter of planting the bug. Everything is made easy here too. All you need is access to the wires somewhere between the phone and the exchange. Ah! There they are strung between building and pole in the street outside. How handy. Most of the time the snooper won't even need access to the premises.

Now for the equipment. Because of the highly sophisticated nature of the modern telephone network, the installation of the a tap is a very tricky business indeed. It will take a capacitor, a pair of high impedance headphones, anything up to two crocodile clips and at least twelve seconds of concentrated effort. If you can't work it out for yourself, Fig.1 shows how it's done. If you connect up while the telephone is in use it will cause no end of pops and clicks. You may hear something like this:

— *This line's very noisy. Do you think someone's tapping the phone?*

— *Don't be silly. Modern phone taps are undetectable. It's when the line's quiet you want to start worrying!* Both laugh. Then exit, pursued by bear.

It can be a little inconvenient, not to say uncomfortable, to sit up a telegraph pole for hours on end. Not that easy to explain either. (It's ... um .. a sponsored pole-perch for charity, officer. The headphones? Um... on-pole entertainment system...)

One alternative to hanging around waiting for the phone to ring is to connect up a tape recorder. Now we come to the really sophisticated electronics: since it's wasteful of tape to run the recorder continuously, it's useful to switch it on only when the phone is being used. Voice operated switches? Why bother. A relay will do the trick (Fig.1b). On the subject of tape recorders, most suppliers of surveillance equipment will stock ones that run at half or a quarter of the normal speed to cram several hours of recording into a standard cassette tape. The results won't be hi-fi, but perfectly good for intelligible voice recordings.

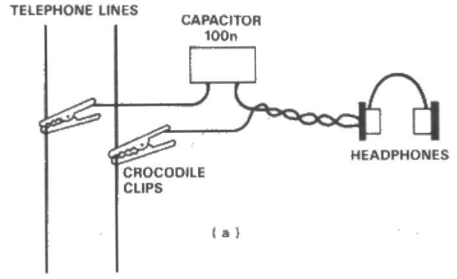
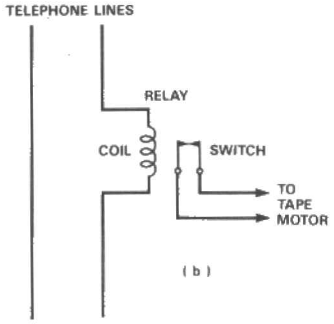


Fig. 1(a) Less than complicated telephone tapping apparatus



(b) adding a relay saves wasting tape

The next step up is to use some kind of radio bug. In the days not so long ago when BT's standard issue telephone was that wedge-of-cheese shaped affair with a dial on the front, a favourite bugging device used to be the 'drop-in' mike. The handset microphone was a carbon granule device, quite bulky but easy to remove: unscrew the mouthpiece, slip off a pair wires from their terminals and it's out. The crafty buggers found a much better use for all that space than filling it with carbon granules. Buying microphones from the very same people who supplied BT, they would empty out the granules, put in a much smaller mike and a small radio transmitter, then seal the whole thing back together again.

Installing the bug couldn't have been easier: pop out the telephone mike, put in the doctored one and screw the mouthpiece back on. Thirty seconds if you take your time about it. The telephone would work as normal and quite a thorough inspection by someone who'd never heard of 'drop-in' would show nothing at all wrong. Of course, everyone in the trade knew about them — it's estimated that the numbers made around the world ran into millions, so they were not uncommon! Still used for bugging public telephones, but not much good for the wide variety of office and home phones now in use.

Also very common and readily available are a variety of bugs which connect either in series with one telephone wire, or in parallel across the two. The series bug has the advantage of only transmitting when the telephone is used; the parallel one transmits continuously in its crudest form (and most commercial bugs are pretty crude) but can be a little more difficult to detect by simple voltage measurements. Let's face it, it would be a trivial matter to design a bug that is both triggered by use of the phone and virtually impossible to detect by voltage measurements, but since almost nobody takes seriously the idea that they may be a

We must remind readers that connection of unauthorised equipment to a public (or indeed private) system is illegal and could lead to prosecution.

suitable target (do you think you are, for instance?) and therefore won't be checking, why bother with anything complicated?

Figure 2 shows an example of a series bug and a parallel one. I don't vouch for either of these circuits — they are lifted from an American pseudo-underground publication from the same bunch who produced the infamous and very nasty Anarchist Cookbook. With the aid of a bridge rectifier, resistor and choke, any of last month's bug circuits can be converted for series operation — the signal appears as a modulation of the bug's power supply, so arrange the input accordingly.

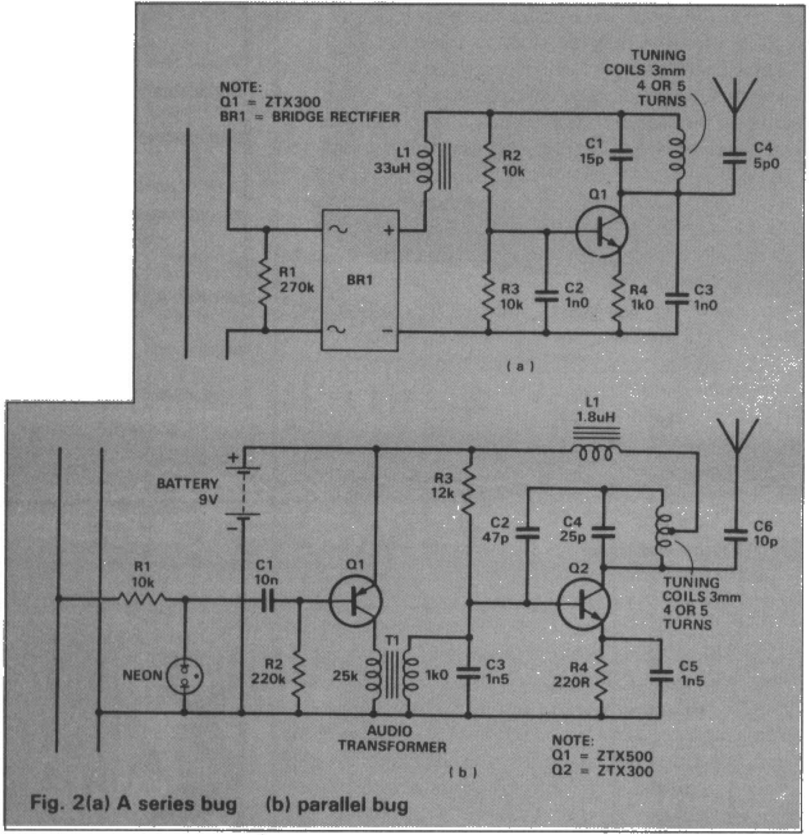


Fig. 2(a) A series bug (b) parallel bug

The most exotic of the commonly used listening devices is the 'infinity transmitter', so called because once the bug is installed, the victim can be snooped on from anywhere in the world. Anywhere his phone can be reached by direct dialling, that is. That is what you do: dial up the victim's number and hold your little back mystery box close to the mouthpiece. In the simplest versions, the mystery box just sends a tone down the line which is picked up by a frequency selective circuit inside the bug. The mystery box activates the infinity transmitter, which you previously attached to the victim's phone. Once activated, the transmitter prevents the phone from ringing, and instead sends down the line any sounds picked up by the victim's telephone, or by the bug's own internal microphone.

This is how it works. On receiving the activating tone, the transmitter passes enough current between the two lines to fool BT's equipment into thinking that the phone has been answered, so the ringing tone is cancelled and the line is opened. Once connection is made, all the bug has to do is to modulate the line voltage in just the way the telephone itself would. Not very difficult. The victim is entirely unaware of anything happening and, with a hookswitch defeat installed, it could be his own telephone acting as a microphone for the transmitter. The bug will automatically cut out if the handset of the victim's phone is lifted, allowing it to be used normally.

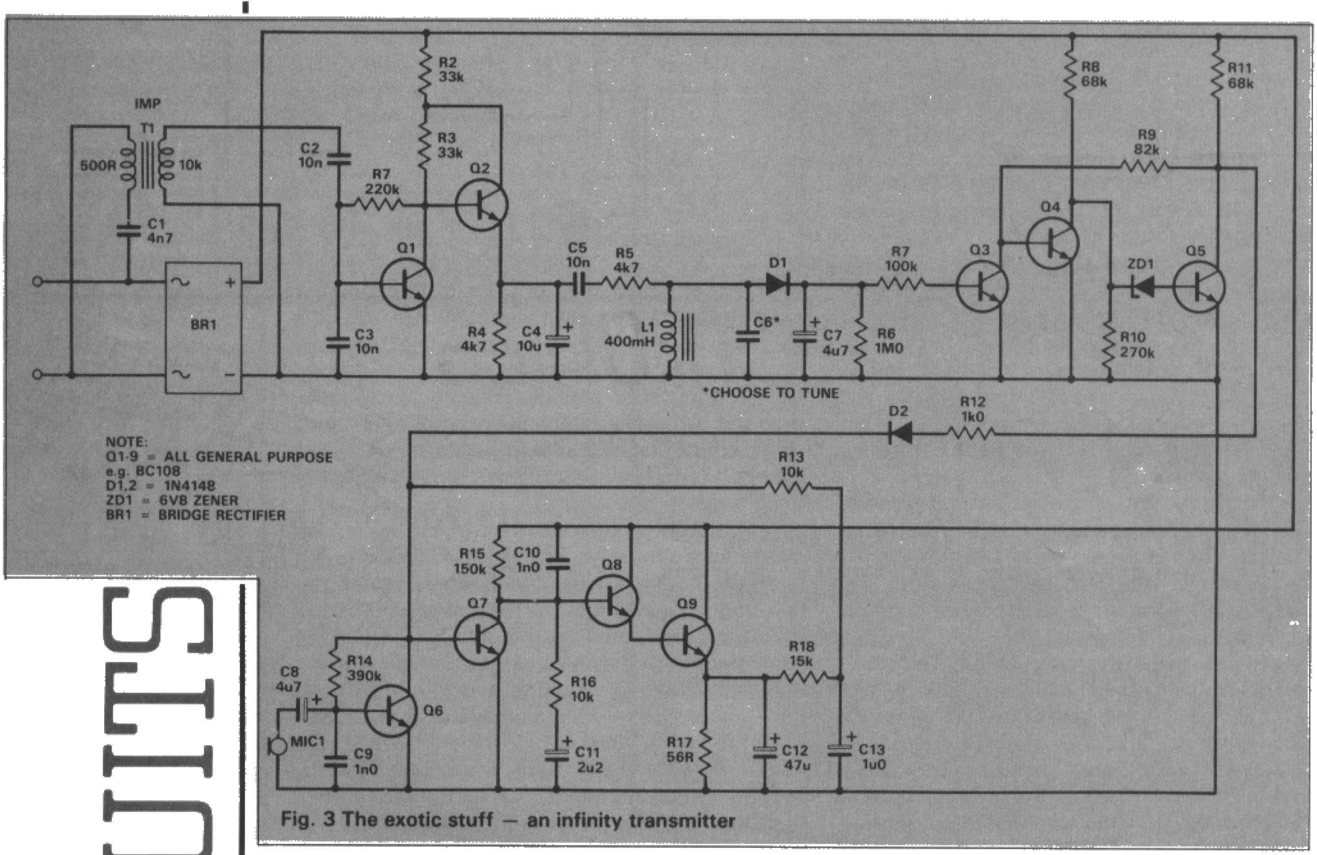


Fig. 3 The exotic stuff — an infinity transmitter

Figure 3 shows an example of an infinity transmitter circuit. Once again, it's a 'borrowed' design, and doesn't look entirely kosher as it stands. To be brutal about it, it's a bodge-it-and-see design, and reeks of self-taught experimenter. But then you can pay serious money for commercial circuits that aren't a lot better. Make of it what you will; it at least demonstrates the principle.

A quick run through the circuit. The transformer picks the activating tone from the telephone line. Q1 and Q2 amplify it from whence it pops into a tuned circuit L1/C1 which makes sure the proper tone is selected. C2 charges up through D1 when the tone is around, causing Q3 to yank downwards on the base of Q4, thereby allowing Q5 to conduct and hold on by way of R1. This keeps the base of Q4 low.

The zener unlatches Q4,5 if the line voltage should drop on account of the phone being used by the victim. Q6 onwards amplifies up the signal from the mike, applying it eventually to Q9 which varies the current drawn between the phone lines, modulating it in much the same way as a carbon mike would.

The purpose of the Q4, 5 latch is, in a round about way, to shut off Q9. When the bug is inactive, Q5 will not be conducting and extra current will be supplied to the base of Q7 via R2, R3 and D2. This should cause Q7 to pull down on the base of Q8, hopefully enough to cut out the current through Q9, and thus most of the loading on the telephone line. When the latch is activated, Q5 conducts and sinks all the current that R3 and D2 were diverting to Q7. D2 prevents it from sinking Q7's normal bias current (derived from the emitter of Q9) into the bargain.

Much simpler than the infinity transmitter, and used in much the same way, is the hookswitch defeat. When you 'hang up' the telephone, a switch disconnects the handset ... unless, that is, somebody has doctored the phone. The simplest method is just to wire a resistor across the switch. In use you phone the victim, apologise for having called up the wrong number, let him hang up but keep your own phone off the hook to hold open the connection. Then you listen in. The sound level won't be very high, so you may need an amplifier.

The difficulty with a plain hookswitch is that you need access to the telephone itself and enough time to dismantle it. There's also the possibility that an innocent caller may be slow to hang up and find himself accidentally eavesdropping. A bit of a giveaway. Hookswitch defeats are easy to spot by anyone familiar with the insides of a telephone, but can often be overlooked in inspection by a suspicious buggee since, unlike infinity transmitters and the like, it could easily be part of the workings of the phone.

Take the idea of 'looking as if it belongs' to its conclusion and you have the 'lost' transmitter. What you do is to find a large-ish component in the telephone (or typewriter, calculator, or whatever) which itself uses any signals you need access to. You then rush home to your garden shed and knock up a device which not only does what this component does, but contains a transmitter too. You package it to look exactly like the component you're replacing. Then you pop back one night and swap the two around. Anyone inspecting the phone or whatever will find it contains exactly the components it should — no more and no less. The transmitter is really and truly lost.

This really is big league stuff — the kind of trick employees of rival governments like to play on each other. Not the kind of thing you will personally come across unless you have access to very valuable information indeed. There's an American company called Fox which could be persuaded to come up with the goodies if you approach them in the right way and have the funds. They're in the phone book.

That's all I'm going to say about telephone tapping, until we come on to the subject of de-lousing your own house, car, office and phone. Do bear in mind that BT are very touchy about having alien equipment connected to their lines, even if it's just a capacitor and headphones. And stay away from my phone, if you don't mind.

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DRAMs

Pete Chown shows that memories are made of this

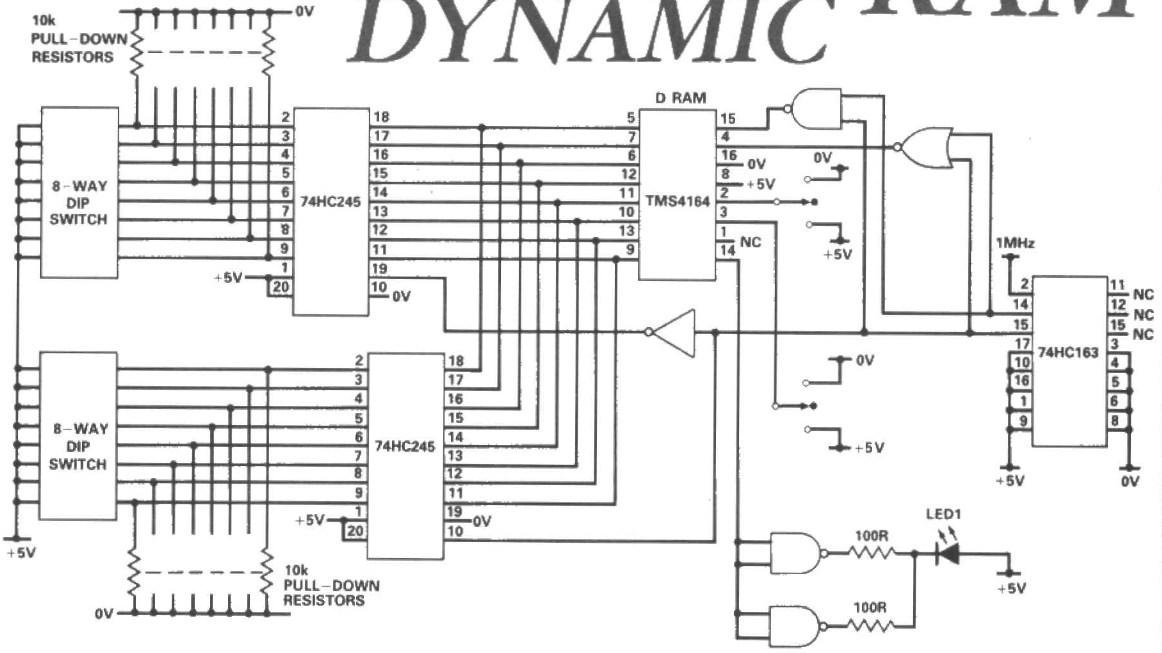

Fig. 1 Circuit diagram of DRAM Interface

Dynamic RAMs are about one quarter the cost of static RAMs. They are also some of the most difficult common ICs to interface. The datasheets assume that you already know how to use the devices and all you need is timing information. With me that was certainly not the case and so I devised an experiment to try to find the answer. The circuit to be described here provides a general purpose interface for the devices. Firstly, it is worth looking DRAMs more closely.

The problems fall into two categories. Firstly there is the problem of ensuring the devices are refreshed with sufficient frequency. This can be done simply by accessing them. It only becomes a problem when battery backup for memory is required because this would normally involve the system clock stopping and the processor not accessing the memory. For this reason, static RAM systems are normally used for battery backup.

The second problem is much more serious. The dynamic devices use multiplexed addressing — otherwise a 50256 (256K) would need log 2262144 = 18 address lines. This would make the devices large and so would increase the area of PCB required for memory.

As it is, the devices use a multiplexed system with two lines, $\overline{CAS}$ and $\overline{RAS}$ (Column Address Strobe and Row Address Strobe) to tell the device which nine bits A0 to A8 are referring to. If this did not make it complex enough, the order in which $\overline{CAS}$ and $\overline{RAS}$ go low affects the operation of the device. In fact $\overline{RAS}$ must go first. If $\overline{CAS}$ goes low first, the device will only be refreshed and no memory access will take place. A list of steps that must be followed for each access of the devices may make this clearer:

i) First address word is placed on address bus.
ii) $\overline{RAS}$ goes low.
iii) Second word is placed on bus.
iv) $\overline{CAS}$ goes low.
v) $\overline{CAS}$ and $\overline{RAS}$ go high.
vi) Valid data appears at the output, or write occurs if R/$\overline{W}$ is low.

During the read or write cycle described above, R/$\overline{W}$ must be held at the correct potential for reading or writing as appropriate and the D_{in} line must show the data to be written into the device, unless you are reading. The whole cycle must take less than a certain time which is dependant on the device being used. It is frequently about 20µs. Obviously no microprocessor will access memory this slowly, and so it only becomes a problem if you are providing a separate oscillator.

If all this sounds very complex, it is not necessary to understand exactly how the devices work to make use of the circuit in Fig.1. As it stands, the circuit allows you to write into a DRAM using 16 DIP switches to control the address and two more to control D_{in} and R/$\overline{W}$.

The output appears at an LED during a read cycle. It is obviously quite pointless to build the circuit as it stands — it doesn't serve any purpose. It is quite easy to adapt and if you wanted to, it could provide a silicon disc for your home computer.

The centre of the circuit is a counter which counts up to four in its two LSBs (Lowest Significant Bits). These are then used to drive the other parts of the circuit. There are four of these — $\overline{CAS}$, $\overline{RAS}$ and the enable lines. The enable lines control two tristate buffers which are used to load the column and row addresses onto the bus at the correct time. In fact the buffers are bus exchangers and could be made to move data the other way (just in case anyone has a datasheet!), and are used as tristate buffers because they are 20p cheaper than the genuine article. A look at the truth table below for driving the circuit allows the appropriate logic to be placed between the counter and the RAM.

Counter outputs Bit 0	Bit 1	$\overline{RAS}$	$\overline{CAS}$	Row address enable	Col address enable
0	0	1	1	Selected	Deselected
0	1	0	1	Selected	Deselected
1	0	0	1	Deselected	Selected
1	1	0	0	Deselected	Selected

It does not matter which enable line goes to row address or column address. This is because the device is symmetrical. Producing the enable outputs is simply a case of driving one from bit 1 and the other from bit 1 through an inverter. You will see that $\overline{CAS}$ is produced by NANDing the two bits together and $\overline{RAS}$ by NORing them. It is therefore now possible to produce a complete circuit for driving DRAMs.

This circuit is complex (to say the least) and is just what you don't need when you are trying to get your latest creation to work. To attempt to fill the gap between dynamic and static, a new breed of devices has recently arrived on the scene — the pseudo-static RAM. These still need accessing frequently to refresh them, unless $\overline{CS}$ is held high and $\overline{OE}$ low, in which case they go into a standby state in which they do not need refreshing. They do not normally have multiplexed addressing, so they can be used almost as static devices.

The snag? Hardly anyone sells them. To order, most sales are to people who buy direct from the manufacturer, which would be alright as long as you wanted a few thousand . . .

There is now a 32K static RAM as well — the HM62256. This offers the equivalent of the BBC Micro's entire RAM on a single chip (the BBC B used 16 16 K bit devices). Finally, to the right is a comparison of the prices of the three types. These are prices quoted by Hitachi, and are subject to change on an almost daily basis. Single devices will be sold, but only to people with an account.

They are also stocked by Farnell (tel: (0532) 636311 account holders only) and Trilogic (Tel: (0274) 691115).

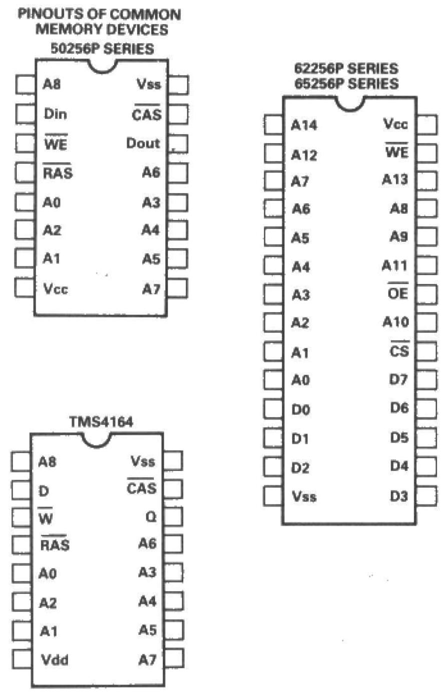

Fig. 2 Pinouts of common memory devices

Device	Access time	Types	Approx Price per single device
HM50256P	120 ns	Dynamic	£5.60
HM65256BP	120 ns	Pseudo-s	£8.20
HM62256P	120 ns	Static	£11.80

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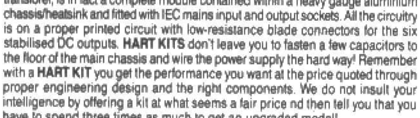

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THE GOOD IC GUIDE

Taking the spotlight this month is the TEA5570 AM/FM radio IC. Paul Chappell adjusts the fine tuning.

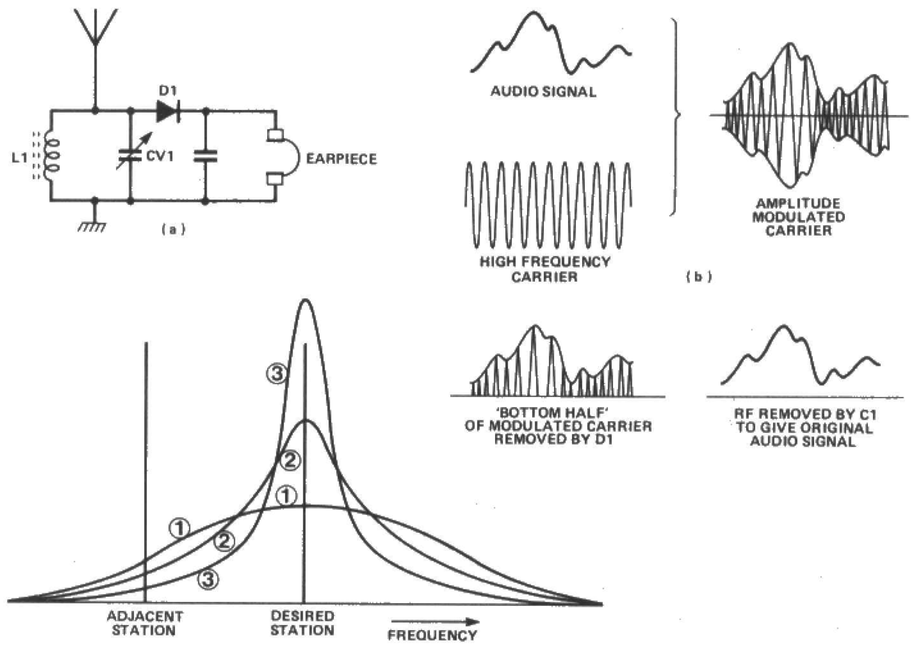
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Fig. 1 (a) The simplest AM receiver (b) Amplitude modulation and demodulation (c) A variety of tuned responses

For knocking together a cheap and cheerful pocket tranny, the ZN414 radio IC has long been a favourite with electronics enthusiasts. With little more than the IC, a ferrite rod aerial, a tuning cap and a resistor, you end up with a circuit which will pull in most of the MW broadcast stations and give enough power to drive a crystal earpiece without any further amplification at all. The ZN416, much the same as the ZN414 with the addition of an output buffer, will drive an earpiece with ease and might just about manage an 80R loudspeaker.

With so much available for so little effort, I'm going to have to make a very good case indeed to convert you to the TEA5570. Although it's not an expensive IC (it actually costs a little less than the ZN416 from most suppliers), a look at the basic MW receiver circuit of Fig. 1a shows that it needs rather more external components. The reason is that the TEA5570 works on the superheterodyne ('superhet') principle, whereas the Ferranti ICs are TRF (tuned radio frequency) circuits. So what difference does it make? Let me explain.

TRF Versus Superhet

A circuit which shows just how simple an AM receiver can be is shown in Fig. 1a. It's an up-to-date version of a crystal set. It contains all the essential ingredients of a TRF receiver except for amplification. The waveforms of Fig. 1b show how the audio signal is allowed to hitch a ride on the RF carrier and how the circuit of Fig. 1a removes it at the other end of its journey. Apart from amplification, the only other addition you'll find in a ZN414 is a means of varying the amount of amplification so that it's cut back on strong signals and cranked up to maximum on weak signals. This is called AGC (automatic gain control).

The limitation of a TRF circuit (amplification and AGC or no), is that it only has one tuned circuit, which makes it difficult to pick out individual stations on a crowded band. The worst situation of all is where you're trying to listen to a weak station and there's a powerful one broadcasting in the next slot along the band. The TRF receiver doesn't stand a chance, whereas the superhet can usually give you the station you want.

This needs a bit more explanation. Take a look at Fig. 1c. The two vertical lines respresent the frequencies (on the horizontal scale) and amplitudes (vertical) of the RF carriers of two adjacent radio stations. On the same diagram are the frequency response curves of various tuned circuits you might build into your radio receiver. By varying the components and the damping of the circuit, you can have whichever of these curves you reckon will give the best results. The tuning can be as peaky or as broad as you like. Now, it seems that to separate the two adjacent transmissions all you have to do is to make the tuning as sharp as possible: you'd go for curve 3. Sad to say, this won't do at all. This is where things start to get complicated, so take a deep breath before going on.

In Fig. 2a I'm putting various tuned circuits to the test. All three look the same, but because of the components I've chosen for each circuit, the first gives the broad tuning of curve 1 in Fig. 1c, the second gives curve 2 and the third gives the sharp tuning of curve 3. This is, let's say, because of the different wire resistances in the three coils. To help with the test, the BBC have kindly loaned one of their broadcast transmitters for the day. Nothing's too good for ETI! All I have to do is phone them and they'll broadcast anything I ask. There's a scope connected to each tuned circuit so we can see exactly what's going on.

The first thing I ask for is a constant amplitude carrier. All the tuned circuits, with their ferrite rod antennae, pick up the carrier OK. Next I ask that the carrier should be reduced in amplitude by a half. The tuned circuits will have to respond to amplitude variations in the carrier, so I check the scopes to make sure that all traces have fallen to half their previous amplitude. They all have. When I ask for other amplitudes of carrier to be sent, all the tuned circuits respond equally well: by the time I get back from the phone I find all traces are showing an amplitude in proportion to the increase or decrease of the carrier amplitude.

Now for the full performance: I ask for the carrier to be modulated with a 5kHz sine wave. Since all the circuits appear to track amplitude variations of the carrier equally well, what I hope to see is all circuits reproducing the continuously modulated carrier equally well. What I actually see is shown in Fig. 2b: circuit one is showing a good reproduction of the modulated carrier, circuit two gives a reduction in depth of the modulation and the carrier from circuit three hardly seems to be modulated at all.

So what's going on? The answer is that although all the circuits will respond to variations in carrier amplitude, the peakier the tuning, the slower the response. Circuit two is having difficulty in keeping up with the 5kHz modulations, circuit three has pretty well thrown in the towel.

Intuitively, you can look at it like this: the better the tuned circuit, the more it likes to do its own thing. Give it a blip of voltage or current and it will continue to produce oscillations for some time afterwards. It's this tendency to go its own way that makes it slow to respond to amplitude variations when driven by a sine wave. The result is that the peakier you make the tuning of a TRF receiver (to improve the selectivity), the more you restrict the audio bandwidth of the receiver. Flatten off the tuning to improve the audio quality and you have the adjacent channel interference back again.

So what's to be done about the situation? To sort that out, we need one more basic idea: the notion of sidebands. If you want to modulate a 1MHz carrier with a 1kHz sine wave, one way to do it is, in effect, to feed the 1MHz sine into a variable gain amplifier and to control the gain with the 1kHz signal. This is more or less what goes on inside an AM transmitter. But in theory there's another way to do it: you add together three sine waves, one at 1MHz, one at 1MHz+1kHz (1,001,000Hz), and one at 1MHz — 1kHz (999,000Hz). Now, although this is not a practical way to amplitude modulate a carrier, the fact remains that amplitude modulation by a sine wave is *exactly the same* as adding three sine waves. The two extra frequencies on either side of the carrier exist, no matter how the wave was modulated, and if the tuned circuit attenuates them then the amplitude variations from the tuned circuit will be cut down too.

Extending this from a sine wave modulation to general audio frequency modulation and instead of a pair of extra *side frequencies*, you end up with extra signals extending away on either side of the carrier for the entire audio bandwidth. The extra frequency areas are known as *sidebands* and the receiver must pick up the whole range without attenuation if the audio signal is to be recovered properly. Figure 3 sums up the situation: it shows two adjacent stations each with carrier and sidebands. It also shows the proper tuning response of the receiver if you're going to end up with both good selectivity and good audio reproduction.

Now all we need to do is to give the receiver a tuning response with a flat top and steep sides. Sad to say, with a single tuned circuit you can't get anywhere near it. If you have more than one tuned circuit to play with, there are several ways you can fiddle about with them to give an approximation to the tuning response of Fig. 3. One possibility is shown in Fig. 4: this is called stagger tuning. You take two or more tuned circuits (three in Fig. 4) and tune them to slightly different frequencies to give an overall response that is fairly flat at the top and steep at the sides. The more tuned circuits you use, the better the results (but the more fiddly the setting up). Another possibility is to have two closely coupled tuned circuits tuned to the same frequency. At resonance one will tend to absorb energy from the other, which will also flatten the top of the tuning curve.

There's no reason not to have more than one tuned circuit in a TRF receiver, but the more you have the more of a problem it is to make them all tune in unison over the entire band. Imagine trying to make six tuned circuits track over the entire medium wave band — you'd need a well-made six-gang tuning capacitor, which would be pretty massive apart from anything else. Then there would almost certainly have to be a pair of trimmers for each tuned circuit to set the top and bottom of the tuning range — what a lot of setting up to do! There's no doubt that the problems could be overcome, but thankfully there's no need to try. The superheterodyne technique gives a simple solution.

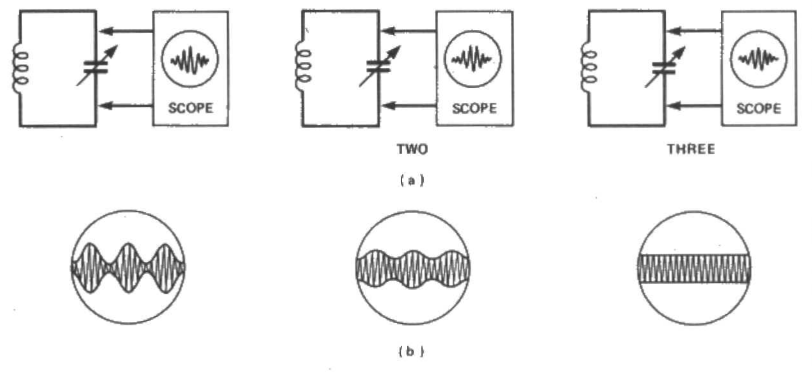


Fig. 2 (a) Three circuits to be tested (b) The test results

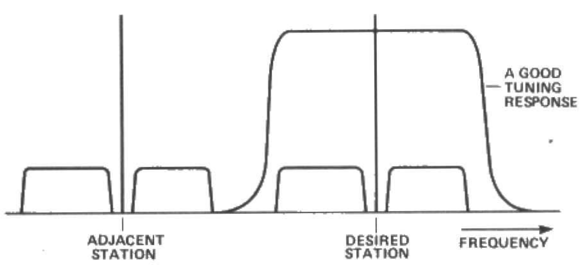


Fig. 3 Good tuning response captures captures the sidebands and rejects adjacent stations

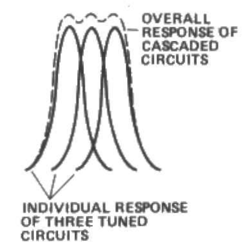
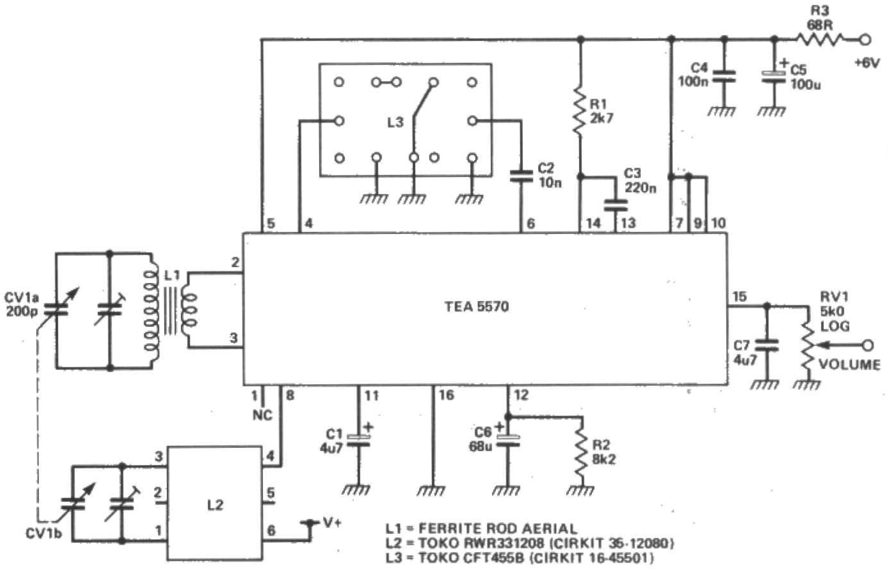

OVERALL RESPONSE OF CASCADED CIRCUITS
INDIVIDUAL RESPONSE OF THREE TUNED CIRCUITS

Fig. 4 One way of achieving a good tuning response: stagger tuning



L1 = FERRITE ROD AERIAL
L2 = TOKO RWR331208 (CIRKIT 35-12080)
L3 = TOKO CFT455B (CIRKIT 16-45501)

Fig. 5 High performance (in comparison with ZN414) MW receiver

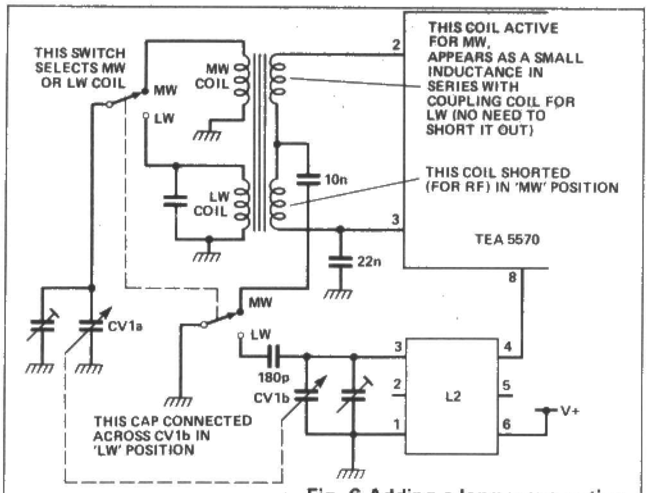

THIS SWITCH SELECTS MW OR LW COIL
MW
LW
MW COIL
LW COIL
THIS COIL ACTIVE FOR MW, APPEARS AS A SMALL INDUCTANCE IN SERIES WITH COUPLING COIL FOR LW (NO NEED TO SHORT IT OUT)
THIS COIL SHORTED (FOR RF) IN 'MW' POSITION
10n
22n
TEA 5570
2
3
8
CV1a
180p
CV1b
L2
V+
THIS CAP CONNECTED ACROSS CV1b IN 'LW' POSITION

Fig. 6 Adding a long wave option

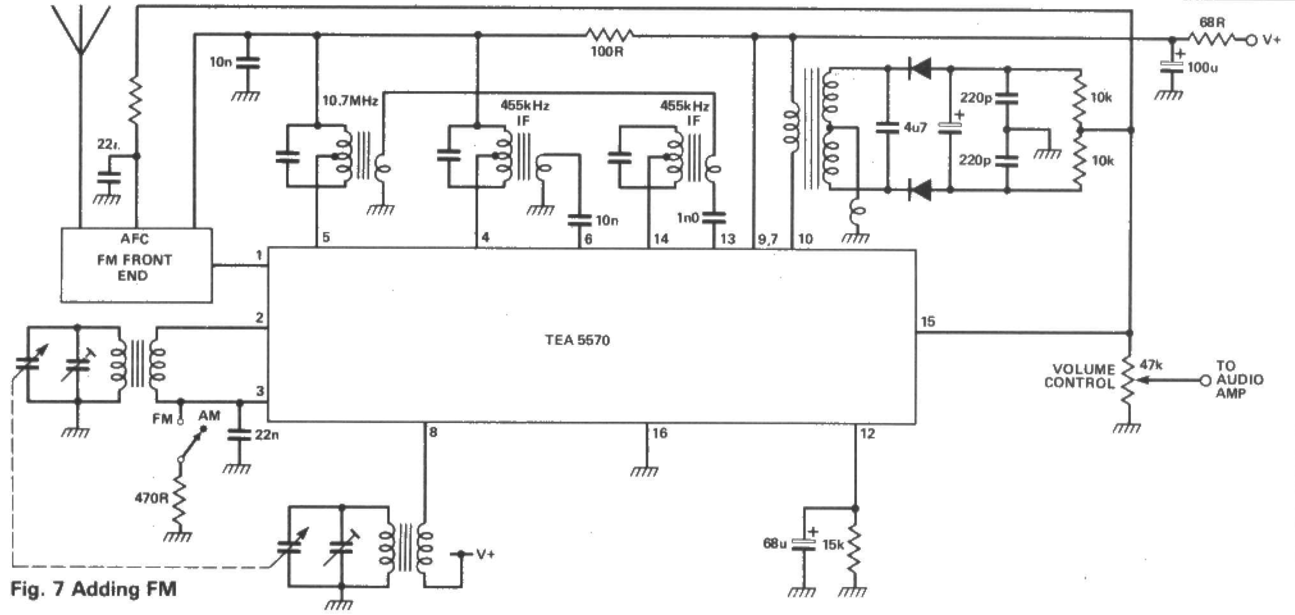


Fig. 7 Adding FM

The way the superhet works is this. At the front end there's the normal tuned circuit to select the station you want to listen to. Tracking with this is an oscillator circuit. For an AM broadcast receiver, the oscillator is set to produce a frequency 455kHz above the selected station frequency: the station tuning and the oscillator frequency are controlled by a two gang tuning cap and the frequencies will always be 455kHz apart.

The next stage is to mix the two signals together to produce sum and difference frequencies. The 'mixing' is usually a fairly crude process: in discrete component radios it more often than not is just a matter of applying the received station signal to the base of the oscillator transistor. The sum and difference frequencies (and in practice a lot of other mush besides) are available at the transistor's collector.

The point of doing this? What you end up with, after filtering out the unwanted sum of the two frequencies, is a 455kHz signal modulated in exactly the same way as the received radio signal. From the mixer onwards it's as if you've got a radio set eternally tuned to the same frequency: 455kHz, known as the *intermediate frequency* or IF. Because of this fixed tuning, you can put in as many filters and tuned circuits as you choose, tailor the response in any way you like. As it's all done at a single frequency, the setting up is as easy as anything.

From the IF stage onwards, the radio circuit continues in much the same way as a TRF set: a detector (the equivalent of the diode in Fig. 1a), an audio amplifier and a speaker.

Figure 5 shows an AM radio circuit using the TEA5570. L1 is wound on a ferrite rod — about 60 turns close wound over the centre of the rod will do for the tuned part, with a four or five turn coil to couple into the IC. L2 is the oscillator coil and L3 is an assembly consisting of two IF transformers and a ceramic filter all in the same package.

As shown the circuit will tune across the MW band. Adding LW is simply a matter of switching out the MW coil and switching in a LW one. At the same time as the LW coil is selected, an extra cap is switched in across L2 to reduce the frequency of the oscillator. Figure 6 shows how.

The TEA5570 will also handle short wave reception up to 30MHz, a decided advantage over the ZN414 and 416, both of which give up the struggle at about 3MHz. For best results, use a separate oscillator coil for the SW bands, although if your main concern is economy you may be able to get away with switching a cap between the top end of CV1b and pin 3 of L2. You won't reach the full 30MHz this way, though.

Now for the FM. Like almost all ICs which claim to be FM receivers, this turns out to be a bit of a con. You can't just plonk a VHF tuned circuit and oscillator coil onto the IC and expect it to do the rest. In essence, all it will do for you is to handle the 10.7MHz FM intermediate frequency and switch between the AM and FM inputs and IF stages as required. You supply the FM front end (RF amp, oscillator and mixer, and AFC circuitry) as a discrete component circuit. Since the TEA5570 doesn't even give you an FM detector, my advice is to forget the FM side altogether!

If you are absolutely determined to have FM too, the easy (though pricey) way to go about it is buy a ready built FM front end. The 10.7MHz output is then fed to pin1 of the IC, as shown in Fig. 7. The remainder of the circuit is taken straight from the data sheet. L2 is the 10.7MHz FM IF stage, L3 and L5 are the AM 455kHz IF stages, and the circuit from pin 10 onwards is the FM detector.

The coils, IFTs, ferrite rods and FM front end are all available from Cirkit, Park Lane, Broxbourne, Herts. Tel: (0992) 444111. The IC can be obtained from JPG Electronics, 276 Chatsworth Road, Chesterfield, S40 2BH. Tel: (0246) 211202.

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E8506-1	Audio Mixer Main	J
E8506-2	Audio Mixer PSU	F
E8506-3	Audio Mixer RIAA	D
E8506-4	Audio Mixer Tone Control	D
E8506-5	EPROM Prog MKII	O
E8507-1	Noise Gate	H
E8508-1	RCL Bridge	N
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E8512-2	MTE Pulse Generator	H
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E8601-3	MTE Counter-timer	M
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E8604-3	Matchbox Amp Bridging Version	C
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E8606-2	MIDI-CV Converter PSU	D
E8606-3	Troglograph	F
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E8609-1	Mains Conditioner	E
E8609-2	Experimental Pre-amp	F
E8609-3	Upgradeable Amp, Tone Board (mono)	H
E8609-4	Upgradeable Amp, Output Board (mono)	F
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E8610-2	Audio Analyser Display Driver	K
E8610-3	Audio Analyser Display	H
E8610-4	Audio Analyser Power Supply	F
E8611-1	Audio Switcher (2 bds)	H
E8611-2	PLL Frequency Meter (4 bds)	Q
E8611-3	Upgradeable Amp PSU	J
E8611-4	Call Meter, Main Board	O
E8611-5	Call Meter, Interface Board	N
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E8706-3	MIDI Keyboard Front Panel	O
E8706-4	Flame Simulator	G
E8707-1	MIDI Keyboard PSU	H
E8707-2	Telephone Alarm	J
E8708-1	Remindalite	F
E8708-3	Rev Counter	F
E8708-4	Car Alarm	F
E8708-5	Knight Raider	J
E8709-1	Boiler Controller	G
E8709-2	Amstrad Sampler (2 bds)	P
E8709-3	Portable PA	G
E8709-4	EEG Monitor (2 bds)	L
E8710-1	Concept CPU Board	N
E8710-2	Concept Power Board	K
E8710-3	Concept Display Board	G

PCBs

E8911-1	Smoke Alarm main board	F
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E8810-4	TV-to-RGB Converter	E
E8810-5	Electron RGB Buffer	C
E8811-1	NiCd Charger	E
E8811-2	Chronoscope (3 bds)	P
E8811-3	Digital Transistor Tester	G
E8812-1	Doppler Speed Gun (2 bds)	K
E8812-2	Small Fry Mini Amp	D
E8812-3	Thermostat	E
E8812-4	Burglar Buster Free PCB	D
E8812-5	Burglar Buster Power/relay Board	E
E8812-6	Burglar Buster Alarm Board	C
E8812-7	Burglar Buster Bleeper Board	C
E8901-1	EPROM Programmer mother board	M
E8901-2	Variat-Ion updated Main Board	H
E8901-3	Variat-Ion Emitter Board	E
E8901-4	In-car Power Supply	C
E8901-5	Granny's Hearing Booster	E
E8902-1	Compressor/Limiter/Gate	L
E8902-2	Ultrasonic Horn	D
E8902-3	Stepper Motor Driver Board	L
E8902-4	Quest-Ion (2bds)	K
E8903-1	Intelligent Plotter Solenoid Board	H
E8903-2	MIDI Programmer	L
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E8904-1	Camera Trigger	E
E8904-3	Intelligent Plotter Main Board	O
E8904-4	Kinetotie Tie Board	N
E8904-5	Kinetotie Control Board	E
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E8906-2	MIDI converter CPU	N
E8906-3	MIDI converter keyboard	N
E8906-4	MIDI converter control	M
E8906-5	AF signal generator	G
E8906-6	Mini bleeper	C
E8906-7	Caravan heater controller	G
E8907-1	MIDI Patch Bay	G
E8907-2	Priority Quiz Switch	E
E8907-3	Camera Trigger Infra-reds (2 boards)	G
E8907-4	Aerial Amplifier main board	E
E8907-5	Aerial Amplifier power supply	E
E8908-1	Intercom master station	L
E8908-2	Intercom slave station	F
E8908-3	Intercom power mixer	E
E8908-4	Digital joystick-to-mouse conversion	H
E8909-1	Twin Loop Metal Locator	H
E8909-2	Trembler movement detector	D
E8909-3	Field power supply (spec 3)	C
E8909-4	Micro monitors active filter	F
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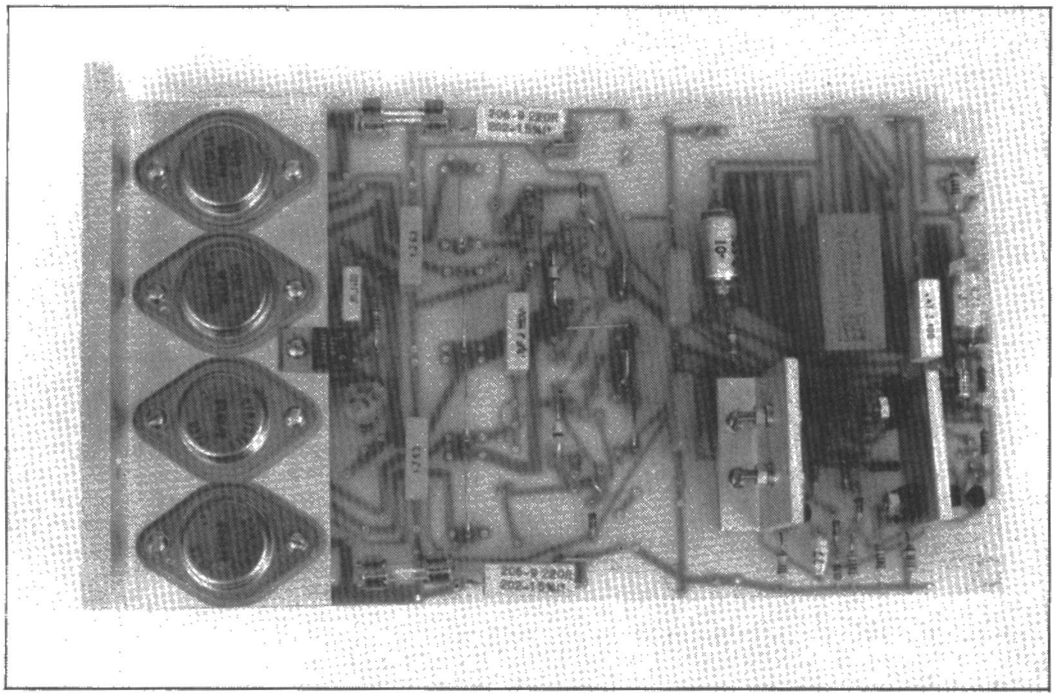
VIRTUOSO POWER AMPLIFIER REVISITED

Graham Nalty's super-fi amplifier receives a MOSFET update



Since the Virtuoso power amplifier was published in ETI (April-June 1988), many people have asked for a kit for a MOSFET power amplifier. In response I have redesigned the Virtuoso, using as much of the original design as possible — if only because I think it is a very high quality design which would be difficult to improve upon.

Most readers will be familiar with the Hitachi power MOSFETs such as 2SJ50 and 2SK135. In the next few months, I hope to have a new integrated amplifer design using the very latest TO-3P versions, but for the MOSFET Virtuoso I am using MOSFETs developed for use in switch mode power supplies. These have the special advantage that they can be directly substituted pin for pin with bipolar darlingtons. This considerably simplifies the redesign.

The output MOSFETs chosen here are the RCA types RFM10N15 (n-channel) and RFM10P15 (p-channel). These are rated at 150V and 10A each with a peak current rating of 25A. Two features of their electrical performance need special care in applying them to any power amp circuit.

Firstly both types exhibit a positive temperature coefficient up to 2A (n-channel) or 6A (p-channel). This means that when the gate voltage is fixed the effect of conduction will cause the devices to generate heat. The increase in temperature will cause a higher current to flow for the same gate voltages and this will increase the temperature further. In bipolar transistors, this effect — thermal runaway — can cause destruction of the output devices. It is usually prevented by placing low value high power resistors in series with the emitters. A further refinement used in the original Virtuoso power amplifier is to make the bias voltage reduce as the temperature of the output devices increases so that the no-load current in the output stays reasonably constant irrespective of temperature. This is achieved by placing Q53 on the same bracket as the output devices. In the MOSFET Virtuoso the presence of Q53 provides more than adequate temperature control of the output so that series resistors in the gate circuit which would degrade the sound quality (upgrading the quality of these resistors in power amps can easily be shown to improve the quality of sound) are not needed.

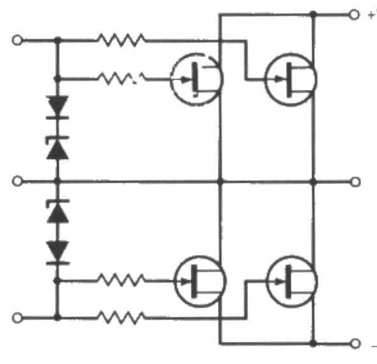


Fig. 1 Output stage protection for the MOSFET Virtuoso

Secondly, conduction does not occur in the RFM10N15 and RFM10P15 until the gate voltage across each device is 3-4V. This means that the bias voltage set by Q53 is around 7V. In practice this is achieved by changing the value of R60 to 150R.

Redesign

Using MOSFET output devices, design of the output stage protection circuit is considerably simplified (see

Fig. 1). It is only necessary to prevent the gate-to-source voltages from exceeding 20V and this can be achieved using a diode and zener diode in series. Also FS2 can be replaced by a link. On consideration of the most likely causes of failure which could cause external damage, this fuse would not afford any additional protection on top of FS3 and FS4. Sound quality will be improved. A 220R resistor is placed in series with each gate to prevent radio frequency oscillation.

The full circuit diagram is shown in Fig. 2. A further change to the design was the removal of Q41, Q42, C56 and changing R48 and R49 to 220R. This change was necessary to eliminate oscillation which occured on a test 'awkward load'. Readers who are tempted to substitute MOSFET transistors for bipolars in other designs should be advised to test the stability performance of the amplifier before use.

Construction

Construction is straightforward except for the installation of the gate resistors. The PCB layout is modified to include positions for the gate resistors on the underside of the board as close as possible to the gates. If you already have one of the original circuit boards you will need to cut the track in six places close to the four gates (see Fig. 3). At two of the gates you will have to cut the track in two places and later join them back, but avoiding connection to gates. When the MOSFETs are in place, then connect the 220R resistors from the gate terminals to the track which originally connected to that position.

A total of nine wire links is needed on top of the boards. Two are used for both bipolar and MOSFET versions in positions reserved for parts only used for the inverting amplifier version (see ETI June 1988). Two are used to link across the base to collector positions of each Q54 and Q55 and the final four are used to link the source of each MOSFET to the output in place of R75, R79, R83, R87. The final link replaces the loudspeaker fuse FS2.

Attach the links first together with the small diodes (1N4148) and resistors, then attach other components in order of ascending size.

Transistors Q45-47 are TO126 cases and are attached to a small aluminium heatsink. Q45, 46 have their metal side facing the input side of the board, Q47 the other way.

Attach the bracket for Q50,51 with fibre washers underneath and mount the transistors — Q50 is insulated from the bracket by a TO220 insulator.

Now fit RV1 and the main heatsink bracket. The four output transistors Q56-59 are mounted via flexible T03 insulators and the gate and source pins are inserted through the PCB. Don't solder them in yet. Attach the 6BA × ¾in bolts via a washer on the top side of the transistor. Insert an insulating bush from the other side into the PCB, into the metal bracket over the bolt. A 6BA solder tag and nut should be attached to the four bolts nearest to the end of the board, a washer and nut on the other four (screw them finger tight). Then attach Q53 with a ¾in bolt, small nylon bush, then Q53, TO220 insulator, bracket, through the PCB to a washer and nut.

Now screw all nine bolts tight and check with a meter for shorts between the transistors and bracket.

Complete the board with C41,42,45,46,48,49, 54,55 (if you are using 'wonder caps' in the upgraded amplifier, you can use the offcuts of wire to parallel all the high current tracks).

Solder all the power transistor leads to the PCB and connect the drains of the TO3 transistors by soldering the solder tags to the PCB tracks. Connect the gate resistors R93-96 from the gates to the track either as described earlier or to undrilled pads in the modified PCB.

To test the amplifier you have built, remove fuses FS3 and FS4 and turn RV1 fully anticlockwise. Connect the power supplies and switch on. Check that the DC offset voltage does not exceed around

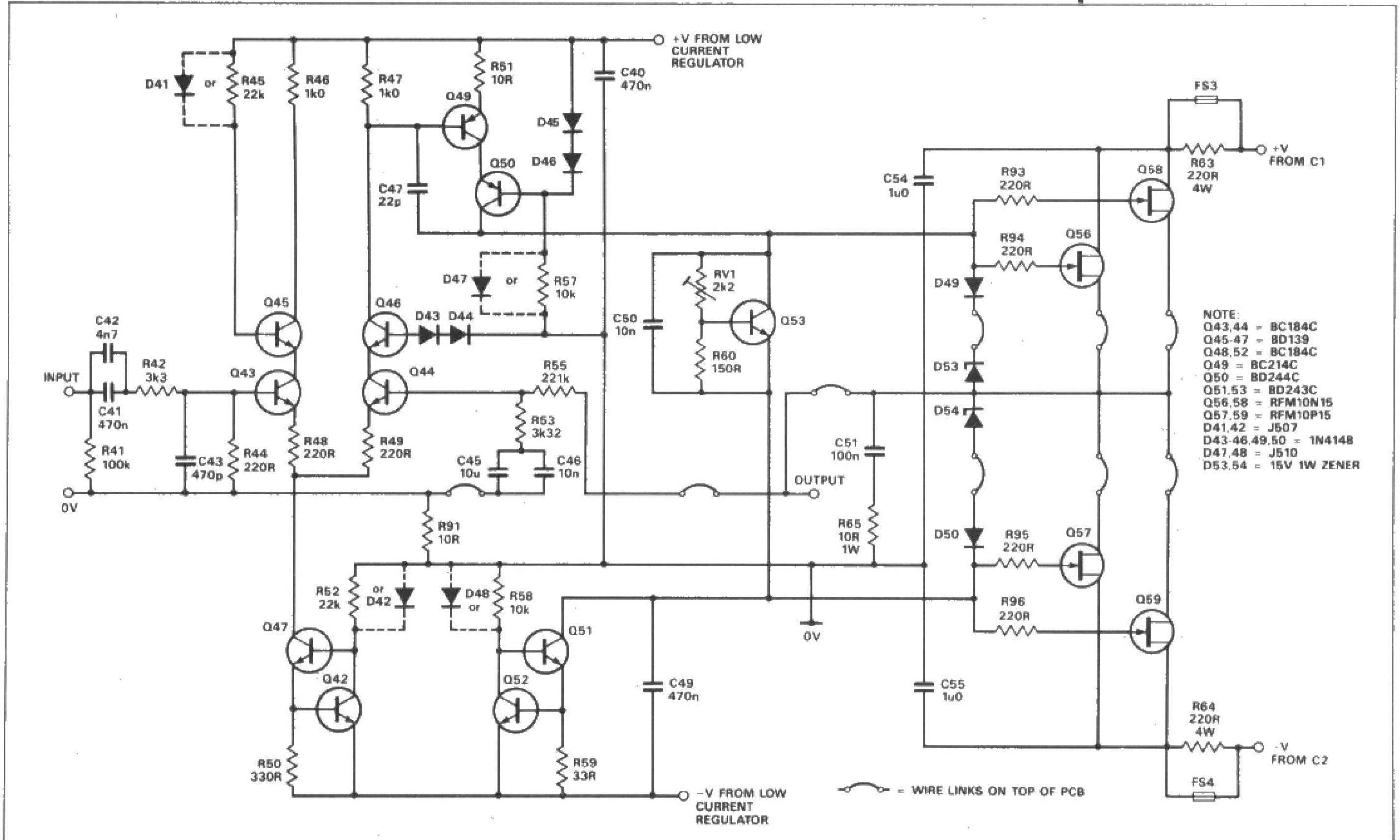
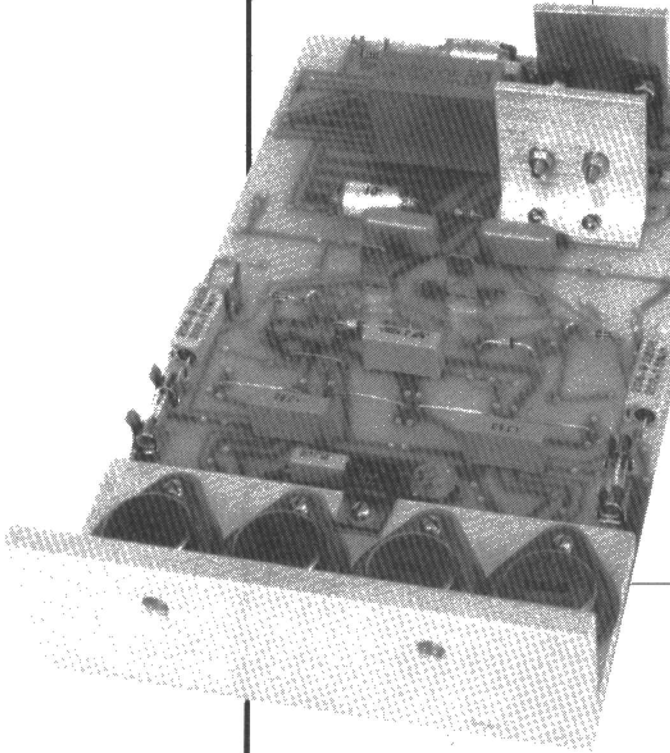


Fig. 2 Complete circuit diagram for the amplifier board



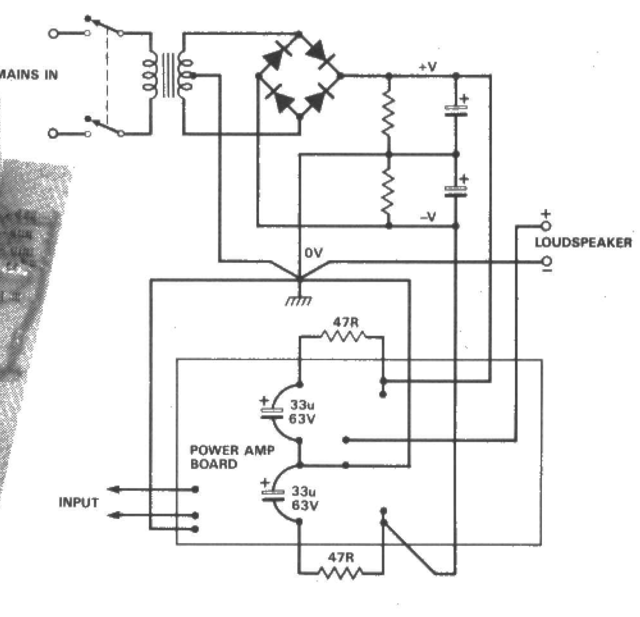
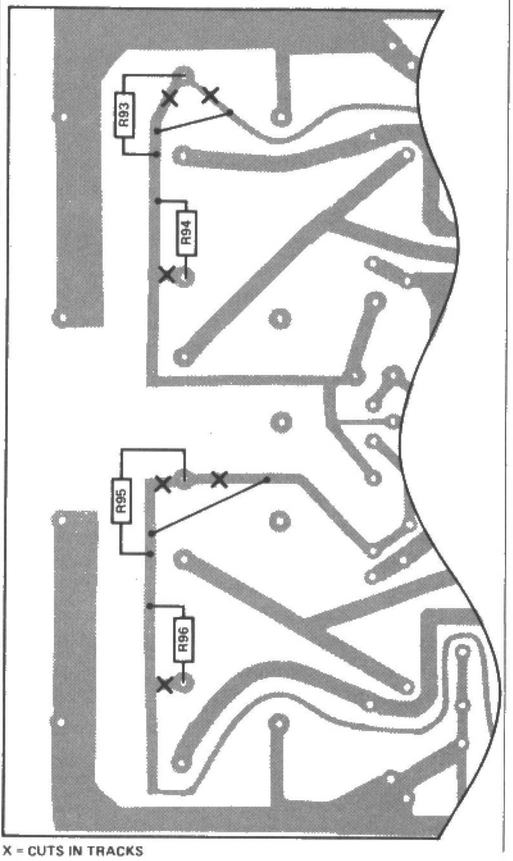


Fig. 4 Connection of the MOSFET Virtuoso to a single supply



X = CUTS IN TRACKS

Fig. 3 Amending the PCB for the gate resistors (replacement foil pattern shown on the foil pages)

250mV (the DC offset will be higher than the original bipolar design due to the removal of Q41 and Q42). If all seems right, turn RV1 clockwise until the collector to emitter voltage of Q53 reaches about 6.8V. Make a fine adjustment until about 30V is measured across R63 and R64. At this setting the output current is around 70mA per MOSFET. If all seems OK, switch off, give the power supply capacitors a few minutes to discharge and insert FS3 and FS4.

The power output of the amplifier was measured in a standard Virtuoso power amplifier to the output stage and with the low current regulators set at ±45V. Output power prior to clipping was measured at 95W into 8R ohms and 170W into 4R.

The MOSFET Virtuoso power amplifier board is designed as part of the complete Virtuoso power amplifier. Ideally it should be used with a high quality power supply such as I described in ETI April and May 1988. The supply voltage of the low current stages must not exceed ±50V due to the voltage ratings of parts used. The supply voltage to the output should be within about 5-8V of the voltage used for the low current side. Ideally it should be used with separate power supplies for the low current and output stages, but will work off single supplies if connected as shown in the circuit of Fig. 4. The use of separate power supplies for low current section and output section gives an improvement in sound quality which does justify the extra cost.

As more enlightened readers will appreciate the MOSFET Virtuoso sounds different from the original design. High frequency sounds are reproduced with greater clarity and with a greater sense of the dynamic — a loud high frequency sounds louder than when using the bipolar output. Initially low frequency sounds are less prominent, due to the extra dynamics of higher frequencies, but bass lines in music are reproduced more clearly as if the MOSFET amplifier has greater dynamic control over movement of the bass cone. Drums are reproduced in a manner which is closer to the real instruments. This effect would be expected to some degree from the removal of the emitter resistors.

The overall effect of the MOSFET amplifier is one which is very close to that of the bipolar version on a brief comparison, but is a quite large improvement in terms of its ability to convey musical enjoyment of the performance.

Further improvements to the performance of the amplifier can be achieved by using a DC servo to extend the low frequency performance and at the same time eliminate the capacitors C45 and C46 in the feedback loop. In future articles in ETI, I hope to describe the design of DC servo circuits that can be applied to any power amplifier and also to preamps such as the Virtuoso preamp.

PARTS LIST

RESISTORS	Standard version	Upgraded version
R41	100k metal film	100k Holco H8
R42	3k3 metal film	3k32 Holco H8
R44	220k metal film	221k Holco H8
R45,52	22k metal film	see D41,D42
R46,47	1k metal film	1k Holco H8
R48,49	**220R metal film**	**221R Holco H8**
R50	330R metal film	332R Holco H8
R51	10R metal film	10R Holco H8
R53	3k32 Holco H8	3k3 Vishay VSRJ
R55	221k Holco H8	220k Vishay VSRJ
R57,58	10k metal film	see D43,44
R59	33R metal film	33R2 Holco H8
R60	**150R metal film**	**150R Holco H8**
R63,64	2204 4W w/w	220R 4W w/w
R65	10R 1W	10R Holco H2
R91	10R metal film	10R metal film
R93-96	**220R metal film**	**221R Holco H8**
RV1	2k2 carbon preset	2k2 cermet preset

MISCELLANEOUS

FS2-4 5A Audiofuse

Printed circuit board. Heat sink bracket. Driver transistor bracket. Input bracket. 4×TO3 insulators. 2×TO220 insulators. 8×TO3 bushes. 3×TO220 bushes. 2×4BA shakeproof washers. 2×4BA × ⅜in bolts. 4×6BA insulating fibre washers. 4×6BA × ¼in bolts. 5×6BA × ⅜in bolts. 1×6BA × ½in bolt. 9×6BA × ¾in bolts. 14×6BA nuts. 10×6BA washers. 9×6BA shakeproof washers. 4×6BA solder tags. 6×PCB half fuseholders. 4× ¼in blades. 4× ¾in × 6BA spacers.

Items in bold are changes or additions to the original parts list.

*Items marked are not required if a DC offset servo is used with the amplifier.

CAPACITORS		
C41	470n polyester	250n EXFS/RP
C42	4n7 polystyrene	
C43	470p polystyrene	470p EXFS/RP
C45*	10u polycarbonate	10μ Wonder cap
C46*	10n polystyrene	10n EXFS/RP
C47	22p polystyrene	22p Silver Mica
C48,49	470n polyester	680n Wonder cap
C50	**10n polypropylene**	6n8 or 8n EXFS/RP
C51	**100n polypropylene**	100n Wonder cap
C54	1μ polyester	1.5μ KP/DMT

SEMICONDUCTORS		
Q43,44	BC184C	MATO2FH (one)
Q45-47	BC139	BD139-10
Q48,52	BC184C	BC184C
Q49	BC214C	BC214C
Q50	BD244C	BD244C
Q51,53	BC243C	BD243C
Q56,58	**RFM10N15**	**RFM10N15**
Q57,59	**RFM10P15**	**RFM10P15**
D41,42	see R45,52	J507
D43,44	1N4148	Red LED
D45,46	1N4148	1N4148
D47,48	see R57,58	J510 (4.7mA)
D49,50	1N4148	1N4148
D53,54	**15V 1W zener**	**15V 1W zener**

BUYLINES

The parts and kits for the Virtuoso are available from Audiokits, 6 Mill Close, Borrowash, Derby DE7 3GU. Tel: (0332) 674929.

Component pack prices for standard £60.00, upgraded board £125.00.

Complete kit price 2U case £330.00 or 3U case £790.00

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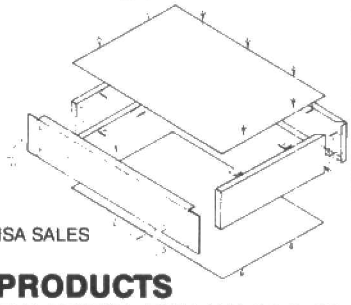

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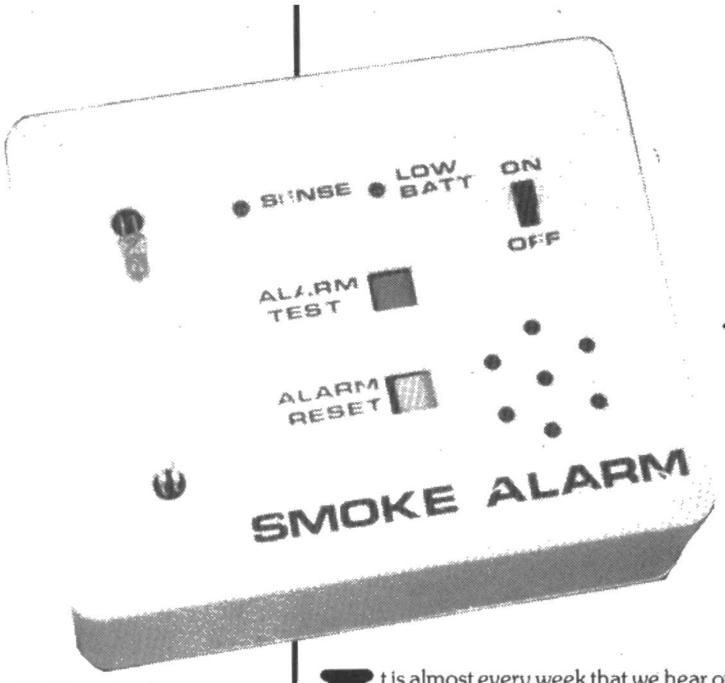
SMOKE ALARM



Gary Calland alerts us to an alarm that can save lives

It is almost every week that we hear of the tragic death of a family caught asleep in the night while their house burns due to a carelessly misplaced cigarette end or faulty electrical equipment. Even the lucky ones who escape the flames have to contend with the prospect of a gutted shell of a house where their home once stood.

Property and more importantly lives could be saved if a fire alarm system were fitted as in all public buildings and work places. However, commercially available comprehensive fire alarm systems are expensive and messy to fit and few people think the risk of fire warrants such a large expenditure.

Recently, small battery-powered fire alarms costing around £20 each have appeared and these provide an acceptable alternative to a full alarm system as two or three units strategically placed around a house can provide complete advanced warning of trouble.

Usually it is not the heat of the flames that kill people but the plumes of choking and often toxic smoke which pour out from burning material. As so much smoke is produced even from the smallest flame, it seems logical to use this smoke to trigger the alarm.

This is often performed by using expensive gas sensors. However the battery powered Smoke Alarm described here uses an equally sensitive but cheaper infra-red beam method of smoke detection which means it costs less to build than most units in the shops. The Smoke Alarm, once triggered, sounds indefinitely until reset. It is loud and piercing and should wake anyone from the deepest sleep.

Battery life was a major consideration in its design and every effort has been made to conserve battery power. When, inevitably, the batteries begin to run down, a red light warns that a battery change will be needed soon. Further drainage of the batteries to an extent that the Smoke Alarm won't work correctly results in the alarm sounding to warn that the batteries need changing now! Alternatively, if the Smoke Alarm is mounted near a mains socket, batteries will be of no worry as the alarm can be powered from a battery eliminator, or by the purpose-built mains unit also described here.

In general, the Smoke Alarm is small, portable and cheap — an attractive alternative to an unprotected home.

A Simple Explanation

Fig. 1 breaks the Smoke Alarm into simple sections so that its operation can be easily considered. The detector circuitry is powered via a constant 5V regulator as the falling potential of a battery with time could interfere with the correct operation of the Smoke Alarm. Any battery voltage in the range 6-9V can hence operate the alarm correctly. The minimum voltage is about 6V and so a red light is illuminated by the low battery indicator section when this voltage is reached.

Smoke particles are detected as the intensity of the infra-red beam is reduced. This reduction is sensed by an infra-red phototransistor. Infra-red waves are used as opposed to ordinary light so the detector is relatively unaffected by external light sources.

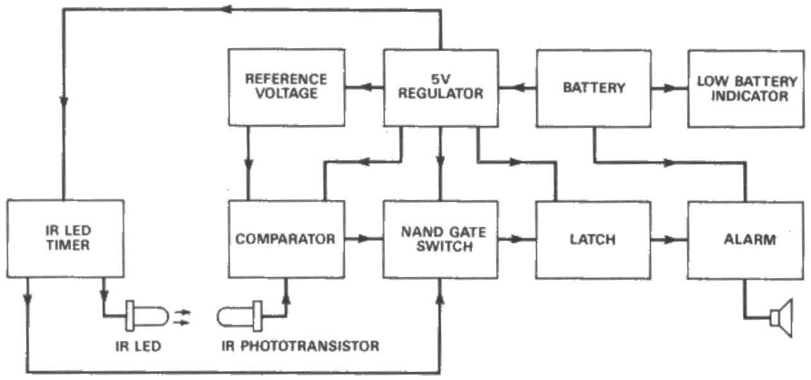
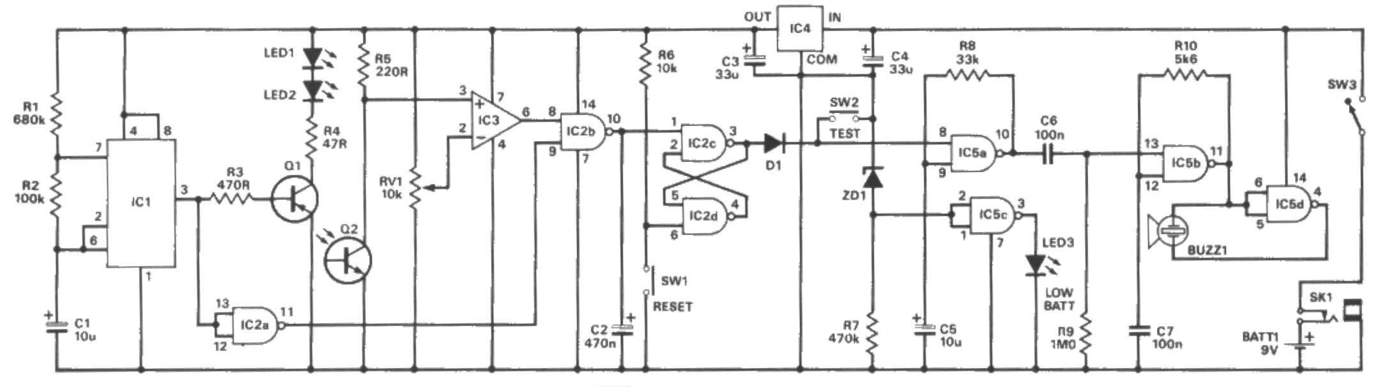


Fig. 1 Block diagram of smoke alarm



NOTE:
IC1 = ICM7555
IC2 = 4011
IC3 = 741
IC4 = 78L05
IC5 = 4093
Q1 = BC212LB
Q2 = TIL78
D1 = OA91
ZD1 = 5V6 ZENER
LED1 = LD274
LED2-3 = RED LEDs
BUZZ1 = PB2720

Fig. 2 Complete circuit diagram for the alarm

HOW IT WORKS

The circuit diagram is shown in Fig. 2. A 5V supply to most of the circuit is provided by the voltage regulator IC4 with the help from C3 and C4. A low power CMOS 7555 timer, IC1 in the a stable mode provides the timing for the infra-red LED. The CMOS version is used to reduce current consumption. Pin 3 is high for a length of time given by T (high) = 0.7 R2C1 seconds. The values shown gives T (high) = 5 seconds and T (low) = 0.5 seconds. PNP transistor Q1 is switched on by a low from IC1 via R3 and illuminates LED1 and LED2 with current limiting by R4. Pin 3 is also connected to a NAND gate of IC2a so that the gates output is high when pin 3 is low.

The changing current through the phototransistor is converted into a corresponding voltage by R5 and is fed to the non-inverting pin of IC3. This 741 op-amp acts as a simple comparator. A preset potential divider RV1 provides a reference voltage which is fed to the inverting pin of IC3 and then compared with the phototransistor voltage. The output from the comparator, either high or low, is fed to pin 8 of NAND gate IC2b. The output from IC2b is usually high, and only goes low when both inputs to it are high. This can only happen when the IR LED is on and the IR beam is attenuated by smoke. See the timing diagram of Fig. 3.

Any glitches produced by the output of IC2b and IC2a are smoothed out by capacitor C2.

The latch is formed by the remaining 2 NAND gates of IC2 and is a set-reset flip-flop. Its two inputs are held by the NAND gate IC2b and the resistor R6. When the set input connected to IC2b goes low the output from the flip-flop changes state and goes high. The output will remain high until the reset input goes low, which occurs when switch SW1 is pressed. The high output switches the audio oscillator circuit on. This is formed by IC5 via diode D1. The audio alarm can be tested by pressing switch SW2 and diode D1 prevents the logic high interfering with the operation of the flip-flop latch.

Diode D1 is a germanium type which drops only about 0.2V across it as opposed to the 0.7V for a silicon type. This is important as a logic high from IC2 is about 4.5V since the I.C is powered from a 5 volt supply. IC5, however, is powered from 9V and has a high/low threshold voltage of about 4V. A silicon diode would drop too much voltage across it and IC5 would always see a low whether the output from IC2 was high or low and the alarm would never sound!

IC5a is activated by a high at pin 8 and oscillates at about 5Hz set by C5 and R8. This switches the oscillator formed by IC5b, C7 and R10 via C6 and R9. C6 and R9 block the DC output from IC5a when it is not oscillating. The resulting pulsed 3kHz tone from IC5b is fed to IC5d, across which a piezoelectric resonator is attached. By connecting the resonator across IC5d rather than from IC5b's output to ground, the voltage fed to the resonator is virtually doubled to 18V so producing a louder sound volume.

The remaining NAND gate IC5c is used for the low battery indicator. About 5V is always maintained across zener diode ZD1. There is about 4V across R7 which is interpreted as a logic high by IC5c, its output is low and LED3 is out. As the battery voltage drops, so does the voltage across R7 until, when the batteries reach 6.5V, the output of IC5c goes high so illuminating LED3.

LED1 draws a considerable amount of current and if left on continually it would quickly drain the batteries. As a result, the IR LED timer only switches the LED on for about ½ second in every 5 seconds. See Fig. 3 for timing diagrams.

The infra-red beam from LED1 shines into the phototransistor a short distance away, and a voltage is produced inversely proportional to the intensity of the beam. This is fed into one input of a comparator, and is compared with a reference voltage at the other input. When an unobstructed beam is present, the phototransistor voltage is lower than the reference voltage and the output from the comparator goes low. See Fig.3. When there is no beam present, or the beam intensity is reduced slightly by smoke, the phototransistor voltage is greater than the reference voltage, and the comparator output is high.

Because the comparator output is high both for no beam and a reduced one, a NAND gate switch is included so that the comparator output is only considered when the IR LED is on (the NAND gate switch output only goes low when a reduced intensity IR beam is detected). A low triggers the latch and audio alarm only to be cancelled when the latch is reset.

Construction

Virtually all the components are mounted on both sides of the PCB to simplify construction as much as possible. Start by mounting the components on the normal side first. See Fig. 4. No specific order is necessary except that the three links should be soldered in first. It is always wise to leave semiconductor devices until last to reduce heat damage as much as possible. IC sockets should be used since this also reduces heat damage and static damage to the CMOS devices.

When this is complete, turn the PCB over so that the copper side is up (see Fig. 5) and solder the two press switches SW1 and SW2 in position leaving about 3-4mm of lead showing. The slide switch SW3 is soldered as close to the PCB as possible. The piezoelectric resonator is soldered in and mounted on top of a plastic tap washer using superglue so that it is several mm from the PCB. The two red LEDs (LED 2,3) should be soldered with their bases about 9mm from the PCB, but the IR LED and the phototransistor should have as much lead showing as possible. In fact the phototransistor will need lead extensions soldered on so that it is in line with the IR LED. They should be left unbent as this stage. The holes for the LEDs and switches can now be carefully drilled and filed in the front of the case. The hole for the optional power socket can be anywhere as long as it does not interfere with the PCB.

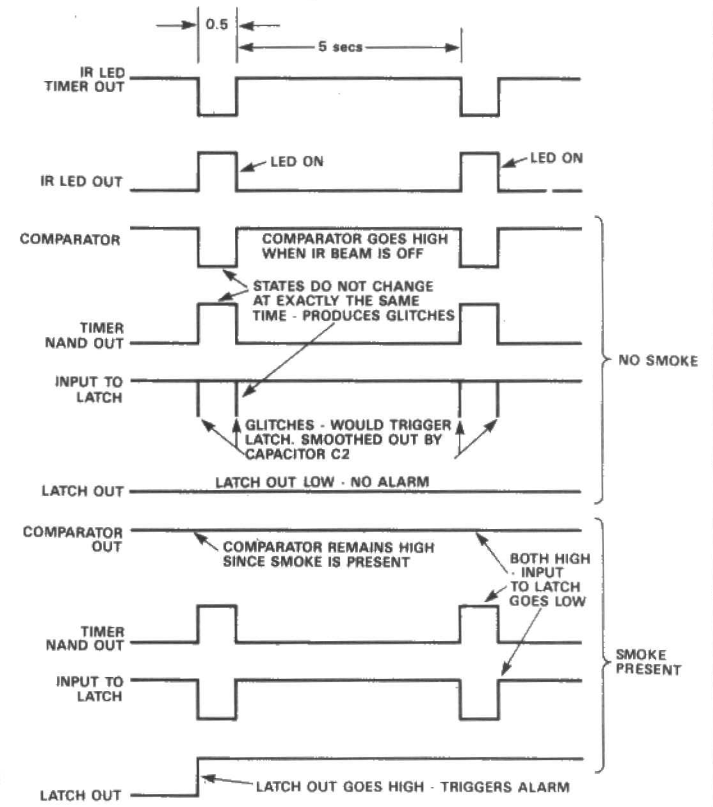

0.5
5 secs
IR LED TIMER OUT
LED ON
LED ON
IR LED OUT
COMPARATOR
COMPARATOR GOES HIGH WHEN IR BEAM IS OFF
STATES DO NOT CHANGE AT EXACTLY THE SAME TIME - PRODUCES GLITCHES
TIMER NAND OUT
INPUT TO LATCH
GLITCHES - WOULD TRIGGER LATCH. SMOOTHED OUT BY CAPACITOR C2
LATCH OUT LOW - NO ALARM
LATCH OUT
NO SMOKE
COMPARATOR OUT
COMPARATOR REMAINS HIGH SINCE SMOKE IS PRESENT
BOTH HIGH - INPUT TO LATCH GOES LOW
TIMER NAND OUT
INPUT TO LATCH
SMOKE PRESENT
LATCH OUT GOES HIGH - TRIGGERS ALARM
LATCH OUT

Fig. 3 Timing diagrams for the complete circuit

The PCB is attached to the case by using 25mm 6BA bolts which are glued onto the inside of the case using Araldite epoxy resin. Alignment of the 6BA bolts is best done as follows. Loosely place the bolts in the PCB holes with their heads on the copper side, with nuts screwed on to prevent them falling out. Put a

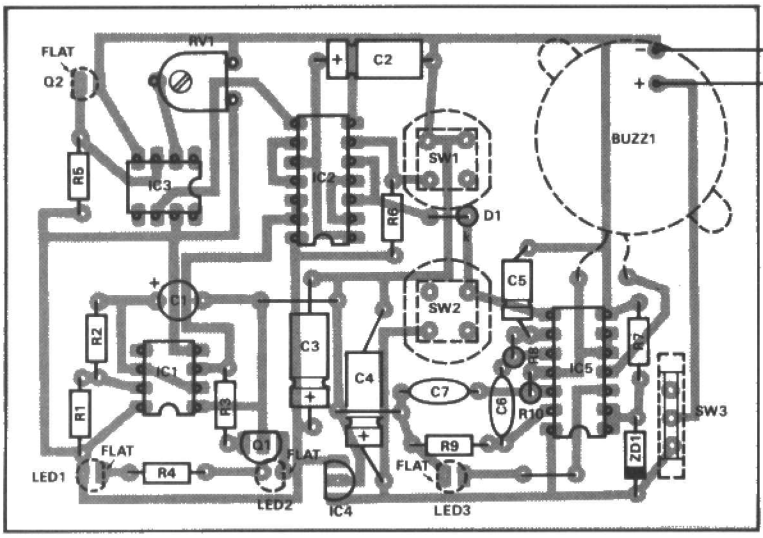


Fig. 4 Component overlay of smoke alarm

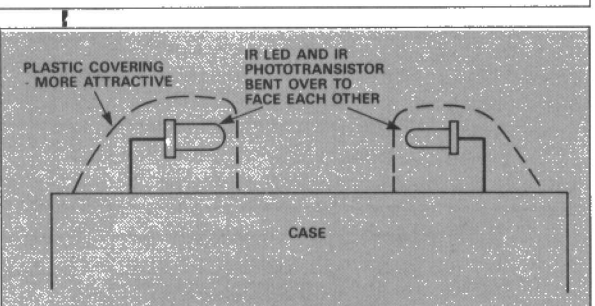

PLASTIC COVERING - MORE ATTRACTIVE
IR LED AND IR PHOTOTRANSISTOR BENT OVER TO FACE EACH OTHER
CASE

Fig. 5 Arrangement of Infra-red LED and photo-transistor

small quantity of epoxy resin on each head and place the PCB in the case so that the LEDs and switches come through the front panel in the desired final position. The bolts can now be accurately positioned and left to set.

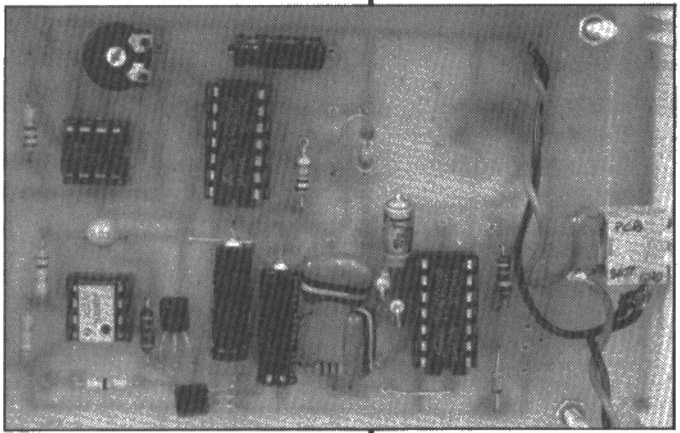
The battery holders are glued onto the case lid using epoxy resin and wiring up is straightforward. All that remains is for the infra-red LED and phototransistor to be bent towards each other as in Fig.6. They can be covered by a plastic pen top or similar to provide a more attractive finish, as long as this does not interfere with the infra-red beam.

Operation

When switched on, the alarm should trigger but this can be reset by the correct button. After this, the *sense* LED should come on every 5 seconds, and the alarm should sound again since the reference voltage will not be set correctly. To do this, firstly make sure the IR LED and phototransistor are accurately facing each other and then turn the preset fully anti-clockwise. The alarm should not sound when the LED comes on. Gradually turn the preset clockwise until the alarm just fails to sound. The alarm is now set, and it should be found that placing a finger or a clear polythene bag in the beam path will trigger the alarm.

External light sources will have no effect on the Smoke Alarm and so correct operation will be maintained day or night. Mean current consumption is less than 5mA and so the batteries should last a considerable length of time. Alternatively, a 7-9V battery eliminator or the mains power supply described may be used.

The cost of the project should be about £10 less case and PCB.



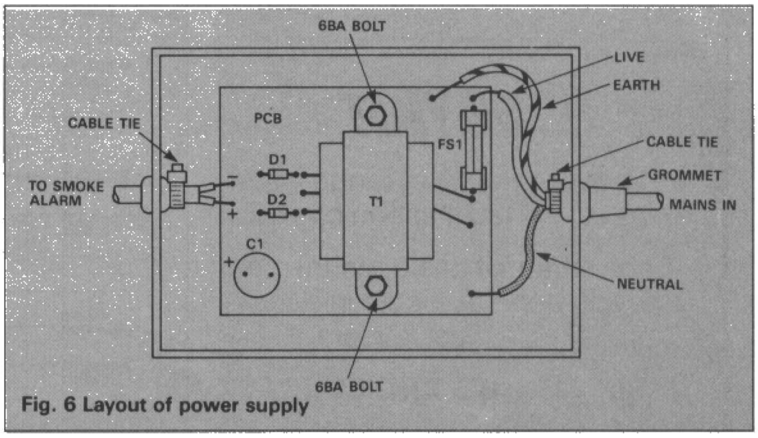


Fig. 6 Layout of power supply

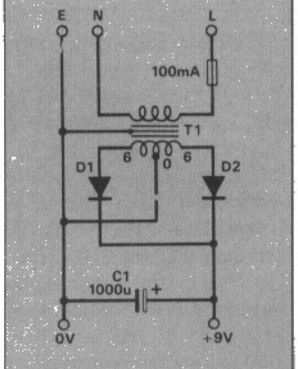


Fig. 7 Circuit of power supply for smoke alarm

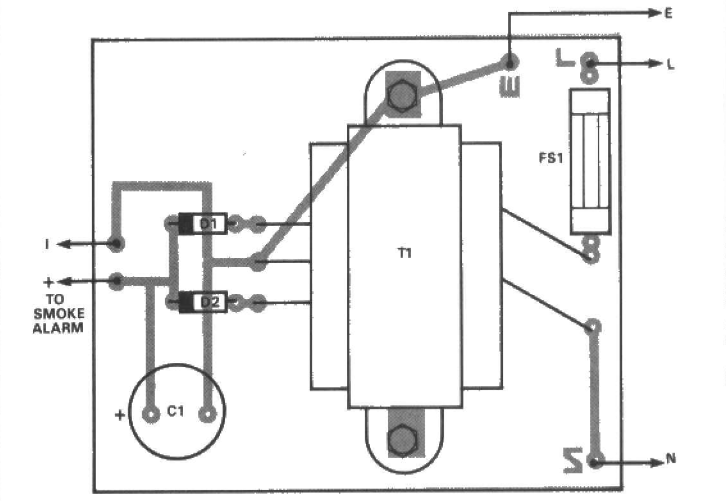


Fig. 8 Component overlay of power supply

PARTS LIST

RESISTORS (all ¼W ±5%)	
R1	690k
R2	100k
R3	470R
R4	47R
R5	220R
R6	10k
R7	470k
R8	33k
R9	1M0
RV1	10k min. horizontal preset
CAPACITORS	
C1	10µ tantalum
C2	0.47µ electrolytic
C3	33µ electrolytic
C4	33µ electrolytic
C5	10µ electrolytic
C6	100n polyester
C7	100n polyester
SEMICONDUCTORS	
IC1	ICM7555 CMOS 555 Timer
IC2	4011 quad dual NAND gate
IC3	741 op-amp
IC4	78L05 5V voltage regulator
IC5	4093 quad schmitt NAND gate
MISCELLANEOUS	
BUZZ1	PB2720 piezoelectric resonator
SW1,2	PCB mounted press switches
SW3	SPDT slide switch

3 2×1 HP7 battery holders. IC sockets, 4 25mm 6BA bolts. 3.5mm jack socket. Case 115×95×37 ABS plastic box. PCB, wire.

Power Supply

If a mains powered version of the Smoke Alarm is to be built and a suitable battery eliminator is not available then this custom designed PSU can be used. Once built the PSU can be used to power other equipment requiring about 9V and drawing less than 100mA of current as well.

The PSU is extremely simple as Fig.7 shows. A mains transformer converts mains 240V into a low AC voltage via a 100mA fuse FS1. This low voltage AC is rectified by diodes D1 and D2 and the DC peaks are smoothed into an unregulated but steady 9V by capacitor C1.

Construction is equally simple, with the few components mounted on the PCB which fits inside any suitable plastic case. See Fig. 8. Note that cable ties are used to prevent the cables from being pulled out from the case. The approximate cost of the supply is £3.00 less PCB and case.

PARTS LIST

D1	1N4007 rectifier diodes
C1	1000µ 16V electrolytic
MISCELLANEOUS	
FS1	100mA, 20mm fuse
T1	6V-0-6V 100mA mains transformer

2 20mm fuse clips. 2 grommets. 2 cable ties. 2 6 BA bolts. Cable, case, PCB.

BUYLINES

Maplin or Electromail can supply infra-red diodes and photo-transistors. Piezoelectric resonators can be also obtained from Maplin. Contact Maplin on (0702) 554161 or Electromail on (0536) 204555.

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BD7	4	in flex switches with neon on/off lights, saves leaving things switched on
BD9	2	6v. 1A mains transformers upright mounting with fixing clamps
BD11	1	6½" speaker cabinet ideal for extensions, takes your speaker. Ref BD137 + 50p.
BD13	12	30 watt reed switches, it's surprising what you can make withe these — burglar alarms, secret switches, relay etc. etc
BD22	2	25 watt loud speaker two unit cross-overs
BD29	1	B.O.A.C. stereo unit is wonderful breakdown value
BD30	2	nicad constant current charges adapt to charge almost any nicad battery
BD32	2	humidity switches, as the air becomes damper the membrane stretches and operates a microswitch
BD42	5	13A rocker switch three tag so on/off, or change over with centre off
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day.
BD49	5	neon valves, with series resistors, these make good night lights
BD56	1	mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through on pole
BD59	2	flat solenoids — you cloud make your multi-tester read AC amps with this
BD67	1	suck or blow operated pressure switch, or it can be operated by any low pressure variations such as water level in water tanks
BD103A	1	6v 750MA power supply, nicely cased with input and output leads
BD120	2	stripper boards each contains a 400v 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers etc
BD128	10	very fine drills for p.c.b. boards etc. Normal cost about 80p each
BD132	2	plastic boxes approx. 3" cube with square hole through top so ideal for interrupted beam switch
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BD139	6	microphone inserts — magnetic 490 ohm also act as speakers
BD149	4	reed relay kits you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets
BD149	6	safety cover for 13A sockets — prevent those inquisitive little fingers getting nasty shocks
BD180	6	neon indicators in panel mounting holders with lens
BD193	6	5 amp 3 pin flush mounting sockets makes a low cost disco panel — need cable clips
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BD259	50	leads with push on ¼" tags — a must for hook ups — mains connections etc
BD263	2	oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress
BD268	1	mini 1 watt amp for record player. Will also change speed of record player motor
BD283	3	mild steel boxes approximately 3" × 3" × 1" deep — standard electrical
BD293	50	mixed silicon diodes
BD305	1	tubular dynamic mic with optional table rest
BD667	2	4.7uf, non-polarised block capacitors, pcb mounting
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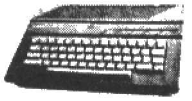

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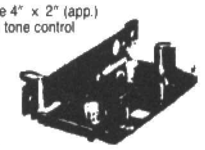

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16 OHM PM SPEAKERS Approx. 7in × 4in 5 watts. Offered at a very low price so you can use two in parallel to give you 10 watts at 8 ohms. £1 for two. Our ref BD684.

EHT TRANSFORMER 4kv 2mA Ex-unused equipment. £5. Our ref 5P139.

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EHT TRANSFORMER 8kv 3mA. £10. Our ref IOP56.

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SOLAR CELLS Will give good current (depending on size) from sunlight or bright daylight. Module A gives 100mA. Price £1. Our ref BD631. Model C gives 400mA. Price £2. Our ref 2*199. Model D gives 700mA. Price £3. Our ref 3P42.

SOLAR POWERED NI-CAD CHARGER 4 Ni-CAD batteries AA (HP7) charged in eight hours or two in only 4 hours. It is complete, boxed ready for use unit. Price £6. Our ref 6P3.

METAL PROJECT BOX Ideal for battery charger, power supply etc., sprayed grey, size 8" × ¼" × 4" high, ends are louvred for ventilation other sides are flat and undrilled. Price £3. Order ref 3P75.

CAPACITOR BARGAIN Axial ended — 4700μf at 25v. Jap made. Normally 50p each, but you will get 4 for £1. Ref 613.

SINLGE SCREENED FLEX 7.02 copper conductors, pvc insulated then with copper screen, finally outer insulation. In fact quite normal screened flex. 10m for £1. Our ref BD668.

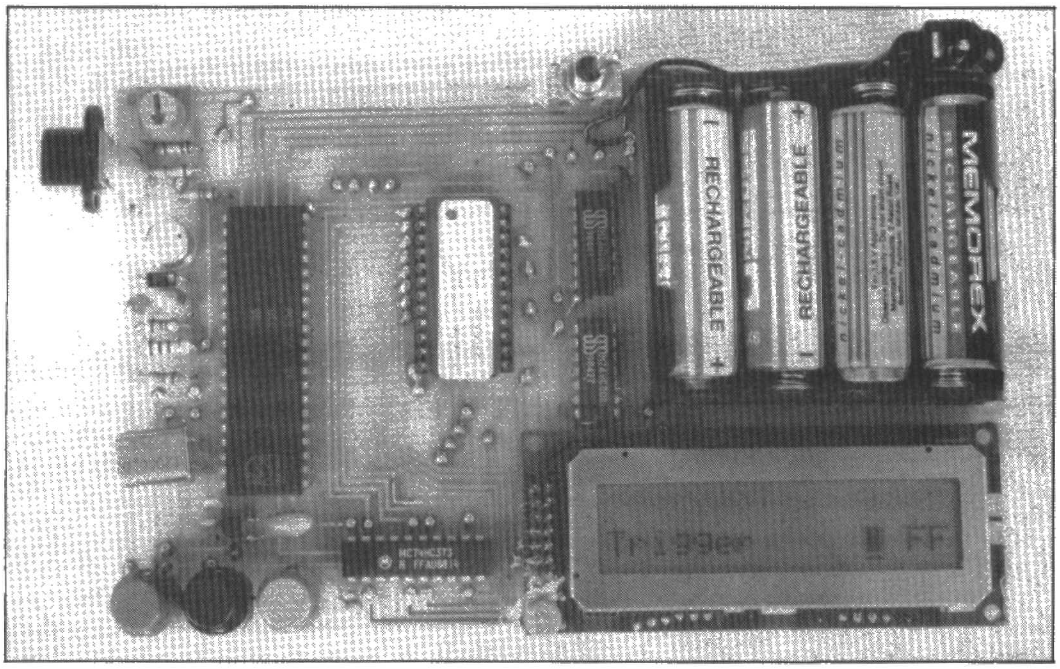
3 CORE FLEX BARGAIN No. 1 Core size 5mm so ideal for long extension leads carrying up to 5 amps or short leads up to 10 amps. 15m £2. Ref 2P189.

3 CORE FLEX BARGAIN No. 2 Core size 1.25mm so ideal for long extension leads carrying up to 13 amps or short leads up to 25A. 10m for £2. Order ref 2P190.

ALPHA-NUMERIC KEYBOARD This keyboard has 73 keys with contactless capacitance switches giving long trouble free life and no contact bounce. The keys are arranged in two groups, the main area field is a QWERTY array and on the right is a 15 key number pad, board size is approx. 13" × 4" — brand new but offered at only a fraction of its cost namely £3 plus £1 post. Ref 3P27.

⅛ HORSEPOWER 12 VOLT MOTOR Made by Smiths, the body length of this is approcimately 3in., the diameter 3in. and the spindle 3/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the end by means of 2 nuts. A very powerful little motor which reves at 3,000rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two year. Price £6. Our ref 6P1, discount for quantities of 10 or more.

SERIAL LOGIC SCOPE



Richard Grodzik shows how serial data can simply be displayed.

PROJECT

This project will allow you to capture serial data and display the alpha-numeric message on an LCD screen. The unit is simple to use and is menu-driven. The data capture and character display allows the display of characters in both hex and ASCII form on the 2-line by 16-character display. The display may be moved forward through the 40-byte buffer by keys which will auto-repeat if held down. A full operating procedure is given. A trigger function allows the user to define a character within the serial data and any message after that point will be recorded.

The Menu selectable parameters are as follows:

Acquire mode: automatic, capturing and displaying any number of characters up to 40.

Receive baud-rate: 150,300,600,1200,1800,2400

Data bits: fixed, 8

Parity: automatic, any

Trigger: off, on (&00H-&7FH)

Serial Data Transmission

To reduce the number of connecting wires required to send digital data over long distance, serial transmission is preferred and in this case requires only two wires, the signal wire carrying the digital information and a common ground return. No handshaking has been included in the design, since the baud-rates (speed of transmission) are relatively low.

Alpha-numeric characters are invariably ASCII coded digital words sent asynchronously, with a start bit, a stop bit and a parity bit framing each 7-bit ASCII character (see Fig. 1) thus forming 10-bit words. Note that this communication protocol, which is known as the RS232 standard, uses logic voltage levels which follow negative logic. TTL level ASCII signals can just as easily be sent in a serial format with just the inclusion of an inverter to satisfy RS232 logic protocol. The reason for higher RS232 logic voltage levels is to provide better noise immunity to long lengths of serial transmission, typically 2000 feet at the lower baud-rates.

ASCII Codes

Codes range from &00 to &7F, the first 20 codes being assigned to control characters. These are the codes produced when a carriage return key is pressed on a computer keyboard. A table of ASCII control characters is shown in Table 1.

HEX CODE	ASCII SYMBOL	MEANING
00	nul	nul
01	soh	start of text
02	stx	start text
03	etx	end text
04	eot	end of transmission
05	enq	enquire
06	ack	acknowledge
07	bel	bell
08	bs	backspace
09	ht	horizontal tab
0A	lf	linefeed
0B	vt	vertical tab
0C	ff	form feed
0D	cr	carriage return
0E	so	shift out
0F	si	shift in
10	dle	data link escape
11	dcl	reserved for xon/xoff handshake
12	dc2	
13	dc3	
14	dc4	
15	nak	negative acknowledge
16	syn	synchronous idle
17	etb	end transmission block
18	can	cancel
19	em	end medium
1A	sub	substitute
1B	esc	escape
1C	fs	form separator
1D	gs	group separator
1E	rs	record separator
1F	us	unit separator
20	sp	space

Table 1 ASCII control characters

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	47k
R2	4k7
R3	100R
R4	5k6
R5	8k2
R6	100k
RV1	4k7
CAPACITORS	
C1-5	100n ceramic
C8,9	33p
C10,11	10µ bead tantalum 16V
SEMICONDUCTORS	
IC1,2	7400
IC3	8031
IC4	2716
IC5	74373
D1	1N4148
D2	LED low current
T1	2N3053
XTAL1	12MHz
MISCELLANEOUS	
SW1-3	Click effect push switch
SW4	SPST toggle switch
SK1	Socket (see text)
BAT	4×AA Nicad

Battery holder. Liquid crystal display. 01in DIL header pins. 0.8mm printed circuit linking pins. Length single-core screened lead. 5-pin DIN domino plug or 25-way D-type socket.

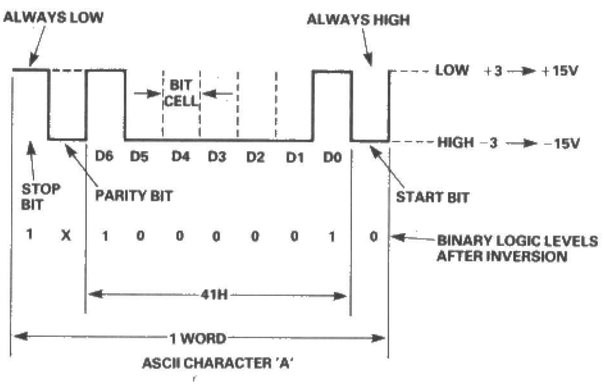


Fig. 1 Format for asynchronous serial data transmission

ASCII codes &21 to &7F are decoded by the display to include all upper and lower case alpha-numeric characters and punctuation signs, as well as the symbol for the Japanese Yen. Are they trying to tell us something?

Construction

The display CMOS device is static sensitive so all precautions should be taken to protect this expensive part. It is recommended that this is the last component to be inserted into the PCB. Short out the connecting header pins with conductive foam. Two rows of DIL 0.1 inch headers are inserted in the LCD connecting holes. Minimum time should be taken to solder these in place. The LCD then can be protected by the con-

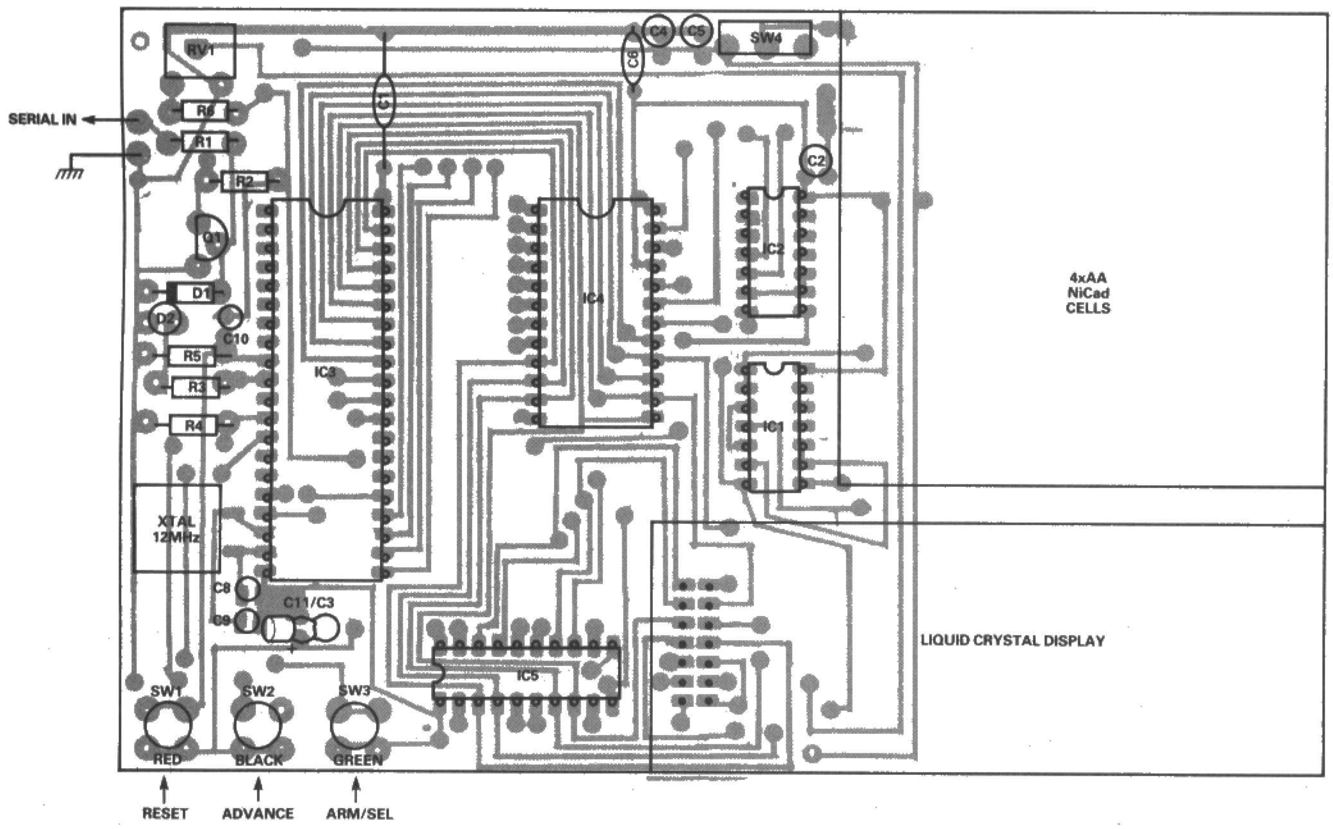


Fig. 2 Component overlay for serial logic scope

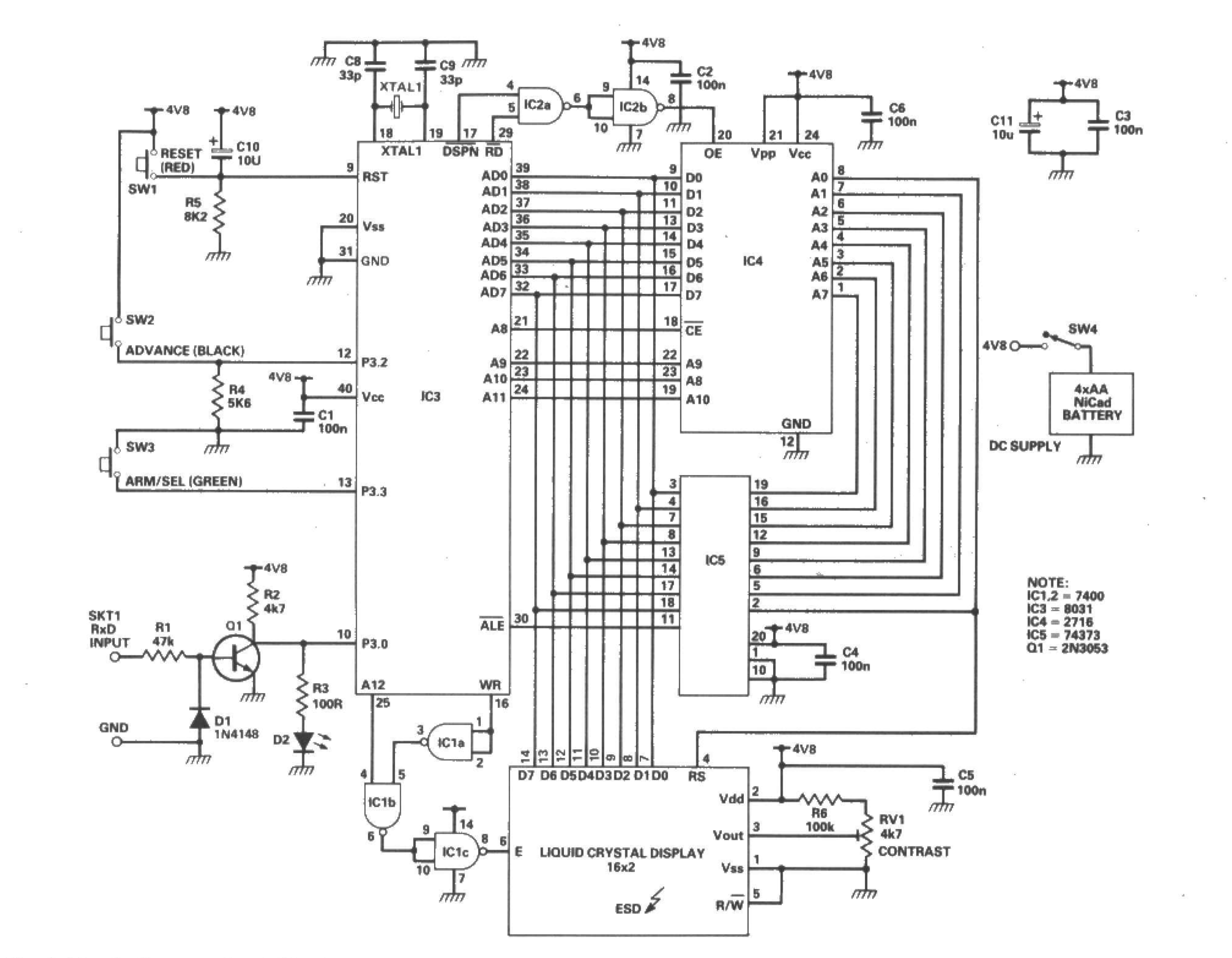


Fig. 3 Circuit diagram of serial logic scope

HOW IT WORKS

The circuit diagram is shown in Fig. 3 and a block diagram in Fig. 4.

The unit is built around IC3 – an 8031 single chip 8-bit microcomputer which incorporates an onboard software programmable UART and 128 bytes of RAM.

The input serial data, RS232 level or inverted TTL level is buffered and inverted by transistor Q1 to present normal positive logic TTL data to the microcomputer IC3. The clamping diode D1 prevents base-emitter reverse breakdown (6V) of the transistor when the RS232 voltage swings to −15V.

Address decoding is provided by IC1 and IC2. IC1a, b and c enable the display when address line A12 is high and the write pin of IC3 is low. IC2a which forms a simple AND gate enable the EPROM data buffer, whilst address line A8 provides the address decoding in conjunction with A10 and A11.

Port 2 of IC3 provides a multiplexed low order address and data bus which is de-multiplexed by octal latch IC5 and IC2.

The liquid crystal display is an intelligent alphanumeric dot matrix module with an integral CMOS microprocessor and LCD display drivers. It utilises a 5 × 7 dot matrix format and is capable of displaying the full ASCII character set.

Three control push switches SW1, SW2, and SW3 are polled in turn by the system software which configures the trigger byte if needed, and receive baud-rate. ASCII data is fed to the microcomputer and saved in its internal RAM, for subsequent output to the display. RV1 provides a contrast control for the display for different viewing angles and ambient light conditions. Finally, the onboard nicads power the unit for approximately five hours with a typical current consumption of 100mA.

ductive foam until final insertion into the PCB, when the foam is removed.

Connecting Up

A single core screened cable is used to connect the unit to any computer. The screen of course is the common ground return (0V). The connections to the BBC model B or Master are to a 5-pin 'domino' DIN plug as shown in Fig 5a. For connecting a PC, a standard 25-way D-type socket is required. This is shown in Fig 5b.

Batteries

Please do not be tempted to use primary zinc carbon or any non-rechargable batteries in place of the NiCds, since you will get a total emf of 6V which is above the manufacturers maximum recommended rated value of 5V for the liquid crystal display. Also reverse polarity battery connections to the display will cause irreparable damage to the expensive display. So double check everything before you power-up.

BUYLINES

The 12MHz crystal is available from Maplin catalogue no. UJ07H. The LCD display is from Electromail catalogue no. 588-516. The 8031 can also be obtained from Electromail. A pre-programmed EPROM is available for £15 inclusive of the EPROM from the author.

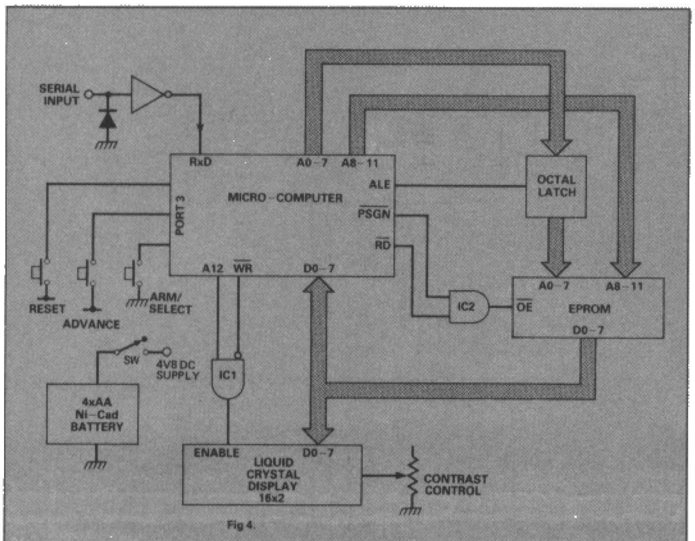


Fig. 4 Block diagram of serial logic scope

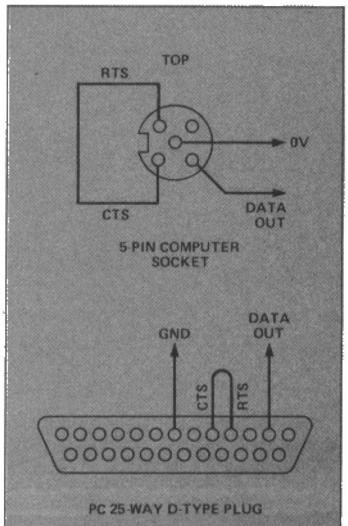


Fig. 5 Connections for the BBC computer or a PC

Software

Two software listings are shown here, one for the BBC in basic, and for those of you with an 8088 Assembler a source program listing which reads the keyboard, prints to screen and sends serial data from the serial port. Communications software is also widely available for the PC, as well as public domain software, notably TELIX. A quick check of the unit can be made by connecting a TTL low frequency source to the input. This will cause random repetitive data to be displayed.

This program reads the keyboard, prints to screen and sends the characters in ASCII format from the serial port.

```
 10 CLS
 20 *FX 8,2                               ;150 baud
 30 *FX 2,2                               ;Keyboard enabled, serial RX on
 40 A=INKEY(1) :IF A=-1 THEN 30           ;If no key press GOTO 30
 45 IF A=13 OR A=10 THEN GOSUB 100        ;Return linefeed?
 50 *FX 3,9                               ;Screen enabled, serial TX on
 60 VDU A                                 ;Display data
 70 *FX 3,0                               ;Screen on, serial TX off
 80 GOTO 30
100 A=10:VDU A
200 A=13:VDU A
300 RETURN
```

NOTE — Line 20 selects the baud rate. Replace 8,2 with the following numbers for different baud rates:

```
*FX 8,3 300 baud
*FX 8,4 1200 baud
*FX 8,5 2400 baud
```

Listing 1 Basic program for BBC computer

This program reads the keyboard, prints to screen and send the character in ASCII format from the serial port. A control C will cause an exit to MSDOS.

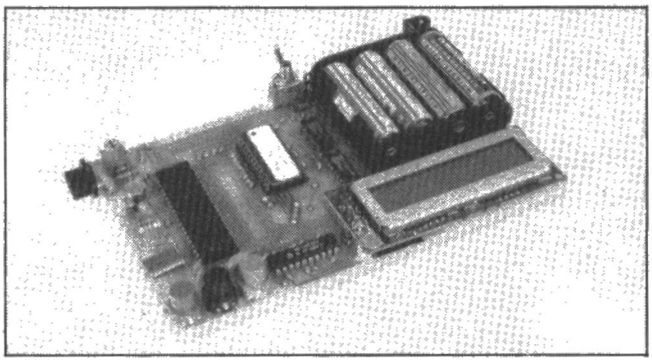
```
SSEG        SEGMENT STACK
            ORG 01000H
            DW 10 DUP (?)
SSEG ENDS

CSEG SEGMENT
ASSUME CS:CSEG,DS:DSEG,ES:DSEG
MAIN PROC FAR
            PUSH DS
            SUB AX,AX
            PUSH AX
            MOV AX,043          ;300 baud rate
            INT 014
            MOV DX,003FC
            MOV AL,003
            OUT DX,AL
REPEAT:     MOV AH,006
            MOV DL,OFF
LOOP1:      INT 021
            JZ LOOP1
            CMP AL,00D
            JZ CAR-RET
            CMP AL,003
            JZ CONTR-C
            MOV DL,AL
            PUSH AX
            INT 021
            MOV CX,08000
DELAY:      LOOP DELAY
            MOV DX,003FD
BACK:       IN AL,DX
            TEST AL,020
            JZ BACK
            SUB DX,+05
            POP AX
            OUT DX,AL
            JMP REPEAT
CAR-RET:    MOV DL,00A
            MOV AH,006
            INT 021
            MOV DL,00D
            MOV AH,006
            INT 021
            JMP REPEAT
CONTR-C:    MOV CX,08000
DELAY1:     LOOP DELAY1
            RET
MAIN ENDP
CSEG ENDS
END MAIN
```

Line 10 of the program defines the baud rate. Following are the values of AX for different baud rates:

023 = 150 baud
063 = 600 baud
083 = 1200 baud
0A3 = 2400 baud

Listing 2 Source listing for PCs



NO TRIGGER

SWITCH ON

RED	BLACK	GREEN
reset	advance	select/arm

```

Trigger                          ■ FF
```

SYSTEM INITIALISED NO TRIGGER BYTE

PRESS SELECT BUTTON (GREEN)

```
150 Baud rate
Trigger                          ■ FF
```

BAUD RATE SELECTED – 150

PROCEDURE G

PRESS ADVANCE BUTTON (BLACK)

```
300 Baud rate
Trigger                          ■ FF
```

BAUD RATE SELECTED – 300

KEEP BUTTON DEPRESSED, RELEASE BUTTON WHEN BAUD RATE SELECTED

BAUD RATES: 150, 300, 1200, 1800, 2400

PRESS SELECT/ARM BUTTON (GREEN)

```


```

DISPLAY BLANKS

SYSTEM ARMED AND WAITING FOR SERIAL DATA INPUT

SERIAL DATA ENTERED

```

The quick brown
```

ALPHA-NUMERIC DATA DISPLAYED

PRESS ADVANCE BUTTON (BLACK)

```

he quick brown f
```

DISPLAY ROTATES

KEEP ADVANCE BUTTON PRESSED

```

456789 The quick
```

SHOWING 40 CAPTURED BYTES

CURSOR INDICATING FIRST BYTE

PRESS SELECT/ARM BUTTON (GREEN)

```
00              T              54
Position        ASCII          HEX
```

BYTE RECEIVED = 1ST   ASCII CHARACTER = T   HEX CODE = 54H

PRESS ADVANCE BUTTON (BLACK)

```
01              h              68
Position        ASCII          HEX
```

SUBSEQUENT CHARACTERS ARE DISPLAYED (Position 00 to 39)

KEEPING BUTTON PRESSED WITH ADVANCE CHARACTER POSITION

PRESS RESET BUTTON RED

```

Trigger                          ■ FF
```

SYSTEM RE-INITIALISED

OPERATING PROCEDURE FOR TRIGGER BYTE

PRESS RESET BUTTON (RED)

```

Trigger                            FF
```

SYSTEM INITIALISED

PRESS ADVANCE BUTTON (BLACK)

```

Trigger                            00
```

TRIGGER BYTE IS 00H

KEEP BUTTON PRESSED, RELEASE WHEN DESIRED TRIGGER BYTE SELECTED

```

Trigger                          8 38
```

ASCII CHARACTER '8'

TRIGGER BYTE SELECTED

PRESS SELECT/ARM BUTTON (GREEN)

```
150 Baud rate
Trigger                          8 38
```

BAUD RATE SELECT MODE

GO TO PROCEDURE 'G'

'MENU DRIVEN OPERATING PROCEDURE'

Table 2 Menu-driven operating procedure

```
0000 79 00 74 20 78 10 F6 08 B8 38 FB 74 00 02 00 40   02A0 20 B2 06 30 98 FA 02 04 71 B9 77 02 80 03 02 00
0010 FF FF FF FF FF FF FF FF FF FF FF 02 04 6E FF FF   02B0 00 12 02 8A C2 AB 75 09 04 75 08 B9 32 FF FF FF
0020 C0 D0 C0 E0 7E 10 1E 7F FF 1F BF 00 FC BE 00 F6   02C0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0030 D0 E0 D0 D0 22 FF FF FF FF FF FF FF FF FF FF FF   02D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0040 78 10 90 10 00 74 11 C0 E0 83 75 6B FF 00 F0 11   02E0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0050 20 D0 E0 04 B4 19 F0 80 0B 00 00 30 38 38 06 0C   02F0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0060 80 02 01 FF 90 10 00 74 C0 F0 11 20 90 10 01 74   0300 90 10 00 74 80 F0 11 20 90 10 01 BB 00 14 74 0B
0070 0B C0 E0 83 F0 11 20 D0 E0 04 B4 17 F4 80 0C 54   0310 C0 E0 83 F0 11 20 D0 E0 04 B4 0F F4 80 04 31 35
0080 72 69 67 67 65 72 20 20 20 20 20 00 00 D2 B3 C2   0320 30 20 BB 01 14 74 0B C0 E0 83 F0 11 20 D0 E0 04
0090 B2 00 00 E5 6B 90 10 01 F0 11 20 74 20 F0 11 20   0330 B4 0F F4 80 04 33 30 30 20 BB 02 14 74 0B C0 E0
00A0 E5 6B 12 04 00 E5 6D F0 11 20 E5 6C F0 11 20 30   0340 83 F0 11 20 D0 E0 04 B4 0F F4 80 04 36 30 30 20
00B0 B3 24 30 B2 FA 05 6B C0 D0 C0 E0 7E 10 1E 7F FF   0350 BB 03 14 74 0B C0 E0 83 F0 11 20 D0 E0 04 B4 0F
00C0 1F BF 00 FC BE 00 F6 D0 E0 D0 D0 74 80 B5 6B 03   0360 F4 80 04 31 32 30 30 BB 04 14 74 0B C0 E0 83 F0
00D0 75 6B 00 02 00 64 00 00 00 00 00 00 00 00 00 00   0370 11 20 D0 E0 04 B4 0F F4 80 04 31 38 30 30 BB 05
00E0 00 00 00 00 00 12 02 BA 30 B3 FD 02 02 00 FF FF   0380 14 74 0B C0 E0 83 F0 11 20 D0 E0 04 B4 0F F4 80
00F0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   0390 04 32 34 30 30 22 FF FF FF FF FF FF FF FF FF FF
0100 C0 E0 54 F0 C4 12 04 16 85 E0 6D D0 E0 54 0F 12   03A0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0110 04 16 85 E0 6C 22 C3 C0 E0 94 0A 40 07 D0 E0 34   03B0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0120 07 34 30 22 D0 E0 34 2F 22 FF FF FF FF FF FF FF   03C0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0130 75 6F 00 90 10 00 74 0C C0 E0 83 F0 12 00 20 D0   03D0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0140 E0 04 B4 14 F3 80 09 30 38 38 06 0C 80 02 01 FF   03E0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0150 79 00 78 10 90 10 01 75 98 50 75 89 20 8C 8D 00   03F0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0160 D2 8E D2 A9 D2 AB D2 AF 00 00 80 FE 80 FC 02 02   0400 12 02 8A 75 6F 00 90 10 00 74 0C C0 E0 83 F0 12
0170 A0 00 00 C2 98 E5 99 A2 D0 B2 D7 54 7F AD 6B F6   0410 00 20 D0 E0 04 B4 14 F3 80 09 30 38 38 06 0C 80
0180 BD FF 02 79 77 B5 6B 02 79 77 B9 77 02 80 03 00   0420 02 01 FF 74 C0 F0 12 00 20 90 10 01 74 0C C0 E0
0190 00 32 C2 AB E6 F0 12 04 A9 08 B8 38 02 80 08 00   0430 83 F0 12 00 20 D0 E0 04 B4 1C F3 80 11 50 6F 73
01A0 00 00 D2 AB 00 00 32 80 07 7F 0B 1F BF 00 FC 22   0440 6E 2E 20 41 53 43 49 49 20 48 45 58 2E FF 7B 10
01B0 00 00 75 09 04 75 08 B9 32 20 B3 03 02 08 00 30   0450 90 10 00 74 80 F0 12 00 20 12 08 B8 00 00 00 00
01C0 B2 F7 90 10 00 74 0A F0 11 20 74 18 F0 11 20 74   0460 00 12 04 00 90 10 01 E5 6D F0 12 00 20 E5 6C F0
01D0 0E F0 11 20 12 02 8A 12 02 8A 00 00 00 00 80 D9   0470 12 00 20 12 08 A0 E6 F0 12 00 20 12 08 A0 E6 12
01E0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   0480 04 00 E5 6D F0 12 00 20 E5 6C F0 12 00 20 30 B2
01F0 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   0490 FD 12 02 8A 08 05 6F B8 38 03 02 08 03 02 08 50
0200 12 02 8A 12 02 8A 90 10 00 74 80 F0 11 20 90 10   04A0 74 0C C0 E0 83 F0 12 00 20 D0 E0 04 B4 11 F3 80
0210 01 74 0B C0 E0 83 F0 11 20 D0 E0 04 B4 19 F4 80   04B0 06 20 20 20 20 20 FF 22 85 6F F0 74 0A C5 F0 84
0220 0F 3F 20 20 20 20 42 61 75 64 2D 72 61 74 65 FF   04C0 C4 25 F0 22 FF FF FF FF FF FF FF FF FF FF FF FF
0230 7B 00 30 B3 0F 12 06 00 30 B2 F7 0B 12 02 8A BB
0240 06 F0 80 EC C2 B4 90 10 00 74 C0 F0 11 20 90 10
0250 01 74 0B C0 E0 83 F0 11 20 D0 E0 04 B4 12 F4 80
0260 08 41 52 4D 45 44 20 20 FF BB 00 02 7C 30 BB 01
0270 02 7C 98 BB 02 02 7C CC BB 03 02 7C E6 BB 04 02
0280 7C EF BB 05 02 7C F3 02 04 30 C0 D0 C0 E0 7E FF   04D0-
0290 1E 7F FF 1F BF 00 FC BE 00 F6 D0 E0 D0 D0 22 FF   END  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
```

Listing 3 EPROM dump

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My wife is an oratorio singer, and sound has to be of very high quality or she will not stay in the room, with 6 Supermos2's driving active isobariks even my wife can now enjoy listening; you have done the Collier family a great service. — Dr. Collier.
I have to hand many upmarket Hi-Fi systems to compare with my Supermos1's, when fed from a Mission PCM 7000 CD feeding Van de Hul 102/2 speakers the sound is marvellous, I am very pleased. I now want to build a Supermos2 system. — E. Andreski.

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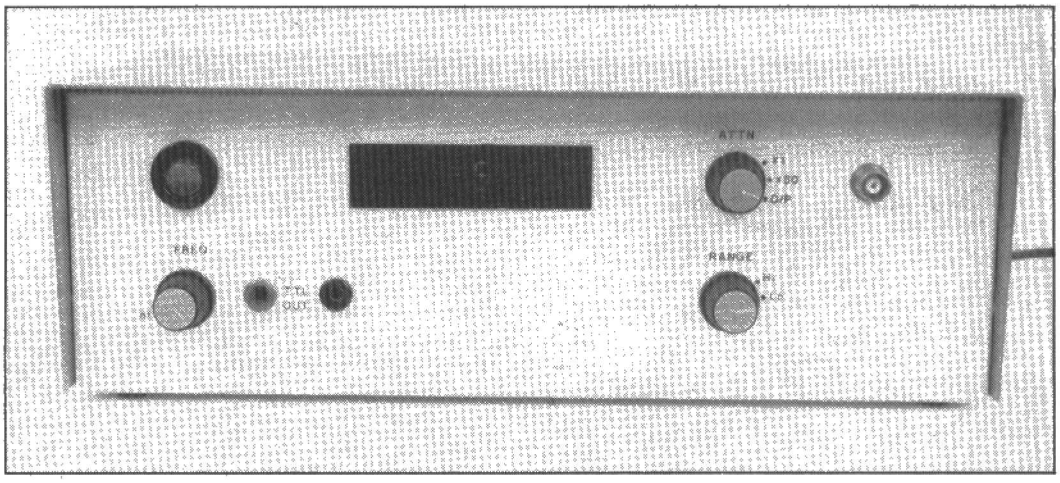

Dennis Stanfield shows how, by careful design, a very low cost frequency meter can be built

Let's face it, a large proportion of the enjoyment derived from a hobby interest in electronics comes out of the designing and building of a project from the germ of an initial idea. When at the end of the process we are the proud possessors of a useful piece of electronic wizardry then the pleasure is of course multiplied many fold, though we would all no doubt admit to having at least a small pile of part constructed projects in a corner somewhere, which we will "get around to finishing sometime."

If, like me, you take a perverse pleasure in doing things your own way you will no doubt begrudge the thought of paying out anywhere between 25 and 30 pounds for a single IC containing almost all the logic circuitry for a frequency counter. After all, part of the fun has gone.

Mind you such chips have, thankfully, effectively disposed of some of the marathons of TTL-based construction which have been seen in the past, with 30 to 40 ICs being common. It is however a fact of life that the amateur constructor purchasing in one-off quantities pays dearly for such convenience.

After some thought it became clear that a frequency counter could be realised using mainly CMOS logic, only reverting to TTL or 74HC devices where such speed was essential. This is possible at considerably less cost than the usual '7216' route and with no penalty in terms of performance or power requirements (in fact, ignoring the prescaler chip all parts except the case should cost about the same, or very little more than a 7216 chip alone).

Although the resulting circuit is more complex, construction is straightforward and any error will not have such dire and costly effects.

The circuit described here is capable of counting to around 200MHz and operates at 5V TTL levels with a power requirement of about 150mA. Accuracy is limited only by the stability and adjustment of the crystal oscillator at the heart of the control gating circuitry.

A little added extra which I have not seen in any other published design is the provision of a crystal controlled square wave output (at TTL 5V level) at 11 spot frequencies in the audio to ultrasonic range. The working prototype excluding case cost £35. How's that for value?

Construction

The counter is constructed on three single-sided PCBs, the design resulting in a minimum of off-board wiring for ease of construction. Although a double-sided board could have been specified for the main logic circuitry the space saving would not have justified the considerably increased costs to those who wished

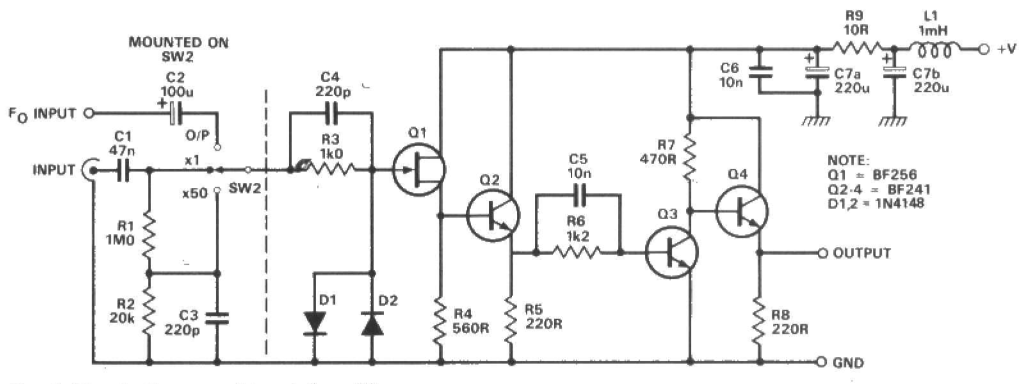

Fig. 1 Circuit diagram of Input Amplifier

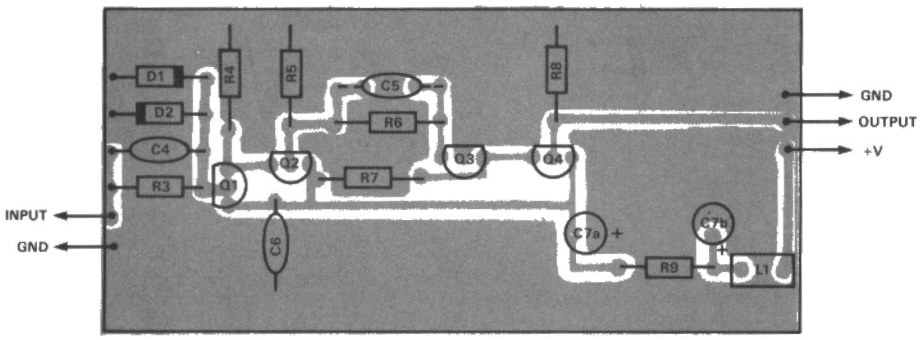

Fig. 2 Component overlay of Input Amplifier

to purchase ready-made boards from the ETI PCB service.

This has however unfortunately necessitated the use of a considerable number of on board wire links but these are, in the main, duplicated through the design and are easy to follow.

The boards comprise an input conditioning amplifier (Fig. 1) housed in a screened case to exclude noise pick-up from adjacent logic circuitry, a main logic and PSU board and finally a display and square-wave output board. In order to keep costs down transistor drivers and standard LEDs of the type available on the 'surplus' market are used. This gives good results at the expense of some added circuit complexity. The display gives a low level output and constructors may wish to experiment further with this (see Fig. 8).

It should be noted that high-efficiency LEDs would give improved display brightness. The current output capacity of the 4511 driver is only about 25mA per segment — and remember that due to the multiplexed display each digit is driven for only 10% of the time resulting in an average of 2.5mA per segment. High-efficiency LEDs were found to give a bright display but standard LEDs are very much less expensive.

It is recommended that the boards be constructed in the order of display, logic, and input amp, as each board may then be used to check the correct operation of each following board. For checking this procedure an unregulated power supply of 9-12 volts is required. All mains potential connections should be sleeved and fully insulated in the case and proper cable strain-relief grommets used as a matter of course. A knot in the cable will not do.

Construction should follow the order of: on-board links, sockets and off-board connectors, passive components and finally transistors, diodes and crystal. Neither ICs nor fuse FS2 should be installed yet. The input amp-conditioner is totally enclosed in a small metal box for screening purposes and holes must be drilled for connecting wires. It is important to ensure that component leads on this board are as short as possible.

Initial Testing

The display may be powered up for testing using the same power supply as before being careful to observe correct polarity (LEDs have a very low reverse voltage tolerance). A 330R resistor must be used in series with the segment drive lead to limit drive current.

With no ICs (except the 7805 regulator) fitted, the main logic board may be powered up and a check made that the correct voltages are present at the relevant points on the board.

If all is well remove the power, remove fuse FS2 and connect an ammeter reading to >200mA across the fuseholder and insert all ICs noting correct polarity.

The display board may now be connected and on re-application of power the meter should read a current of around 150mA. If not switch off and recheck your work, especially correct polarity of components.

If the count input pin is connected to 0V, the display should settle to a 0 reading at the least significant digit. Connect a flying lead between +V and point 'X' on Figs 3 and 4 (above R22) and all eight digits should light '0'. When completed, the input amp may be connected and a signal applied.

Assembly

The front and rear panels are drilled out and all holes should be de-burred and the paint removed from around the rear of the aperture for SKT1 and from around the transformer mounting holes to ensure a good earth connection.

Front panel legends on the prototype are rub down transfers of the type available from Maplin, the 2.5mm series being a useful size for this application. The display is mounted with the overlapping filter hiding the countersunk screw heads.

All inter-board connections use 0.1in or 0.2in connectors to make any service work easy, when required. C1 is mounted directly behind the input socket and C2, C3, R1 and R2 are all soldered around switch SW2.

A final check over the interconnections and the mains wiring should be made and if all is well power can be applied. After 1-2 seconds the display will stabilise reading 0Hz.

Setting Up

It should be noted that the 8629 prescaler in the high range will read quite low frequencies provided these have very fast rise and fall times (10s of nanoseconds) but the rather lazy risetime of sine or triangle waveforms will give misleading readings at much below 10MHz.

Count accuracy is set by adjusting CV1 which varies, over a very small range, the oscillation frequency of the 4060/XTAL oscillator. This must be done while feeding the unit a precisely known input frequency, at as high a frequency as possible on the low range — say around 30MHz. The building of a test crystal oscillator is not recommended unless a known counter is available for comparison, as that crystal may also have an adjustment tolerance and we would be simply transposing any error.

Once a correct test readout is obtained the case top should be fitted loosely and the counter and

NOTE: SEE ETI
APRIL 1990 P58
oops! FOR
ERRORS/CORRECTIONS

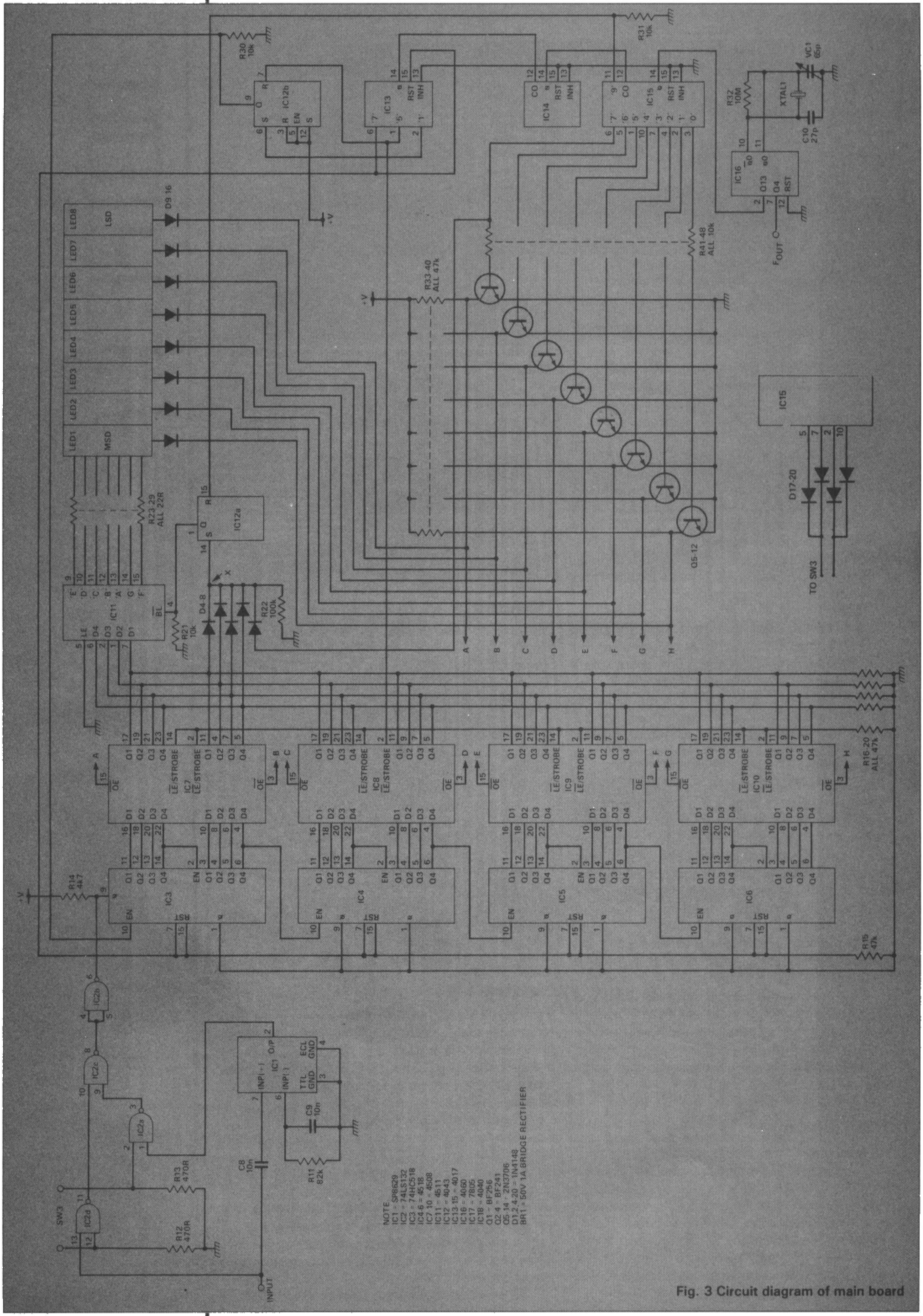

Fig. 3 Circuit diagram of main board

PARTS LIST

RESISTORS (all ¼W 5%)

R1	1M
R2	20k
R3,51	1k0
R5,8	220R
R6	1k8
R7,12,13	470R
R9	10R
R11	82k
R14	4k7
R15-20,33-40	47k
R21,30,31,41-49,52	10k
R22	100k
R23-29,50	22R
R32	10M

CAPACITORS

C1	47nf 400V
C2	100µ 10V
C3,4	220p
C5,6,8,9	10n
C7A,7B,14	220µ 10V
C10	27p
C11	220µ 16V
C12,13,15-22	100n
CV1	Trimmer 65p

SEMICONDUCTORS

IC1	SP8629
IC2	74LS132
IC3	74HC4518
IC4-6	4518
IC7-10	4508
IC11	4511
IC12	4043
IC13-15	4017
IC16	4060
IC17	7805
IC18	4040
Q1	BF256
Q2-4	BF241
Q5-14	2N3706
D1,2,4-20	1N4148
BR1	50V/1A
LED1-8	FND353 or hi-brightness LED

SWITCHES

SW1	on/off DPST
SW2,4	rotary 1P12 way
SW3	rotary 3P4 way

MISCELLANEOUS

XTAL1	3.2768MHz
T1	12V/250mA
L1	min 1mH
FS1	Chassis fuseholder & fuse
FS2	PCB fuseholder & fuse

IC Sockets — all except ICs 17, 18. BNC chassis socket. 4mm chassis sockets. Knobs. PCBs. Shielded box 100×50×25mm. Case.

BUYLINES

Components were obtained from various sources. The pre-scaler can be obtained from Watford Electronics, tel: (0923) 37774. Chips from Grandata Ltd tel: 01-900 2329. Transformer and passive components from Maplin, tel: (0702) 554161, and the displays from Bi-Pak.

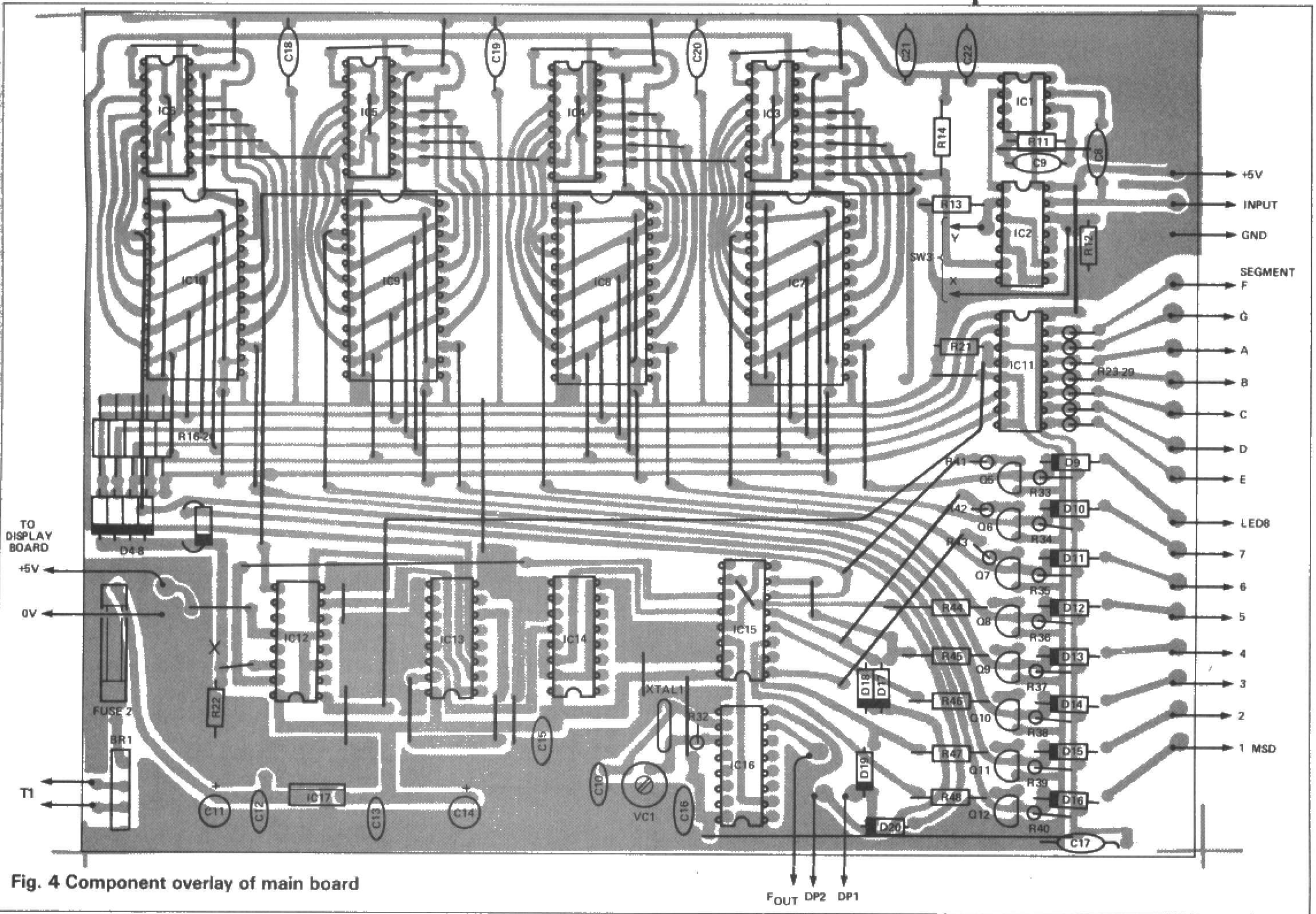

Fig. 4 Component overlay of main board

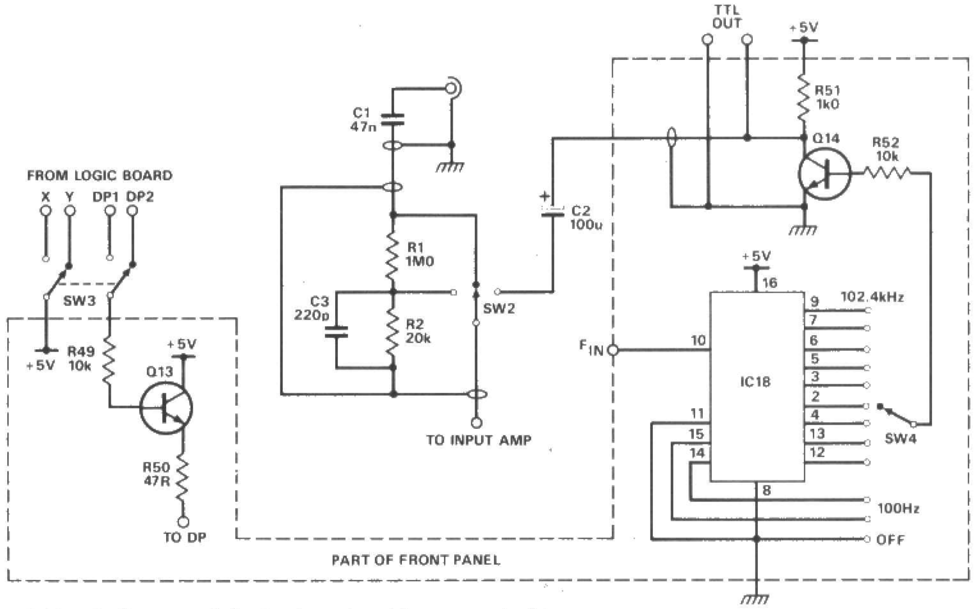

Fig. 5 Circuit diagram of display board and front panel wiring

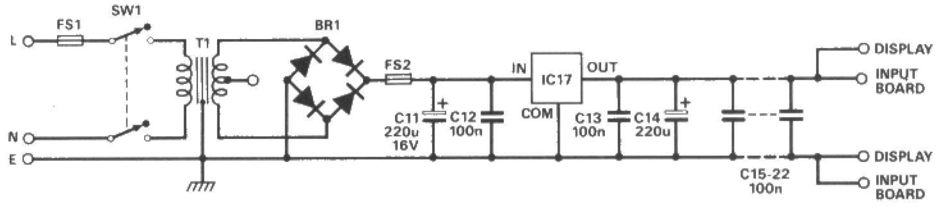

Fig. 6 Circuit diagram of power supply

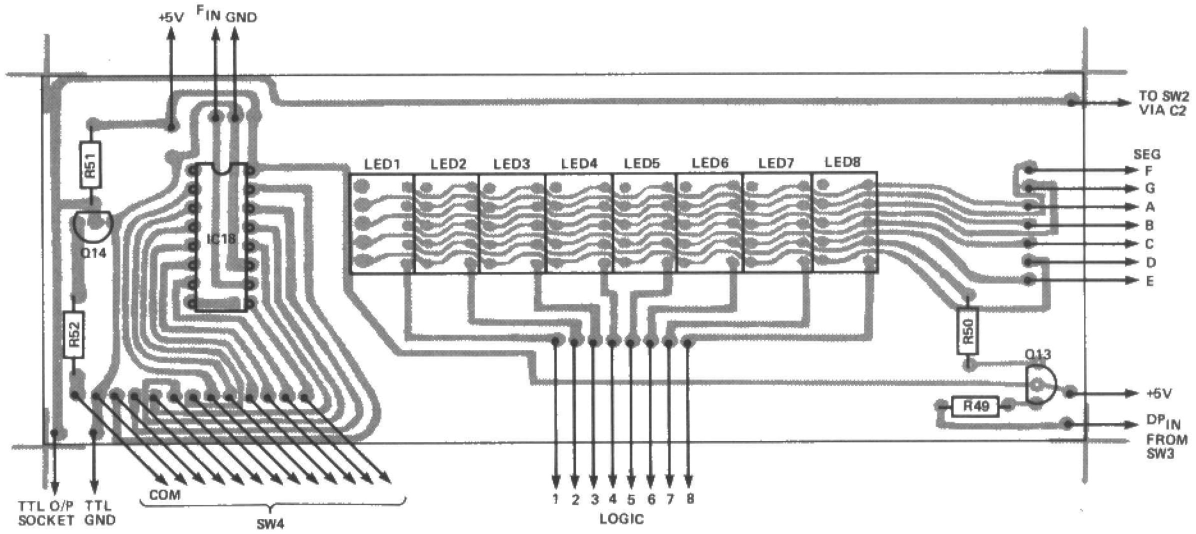

Fig. 7 Component overlay of display board

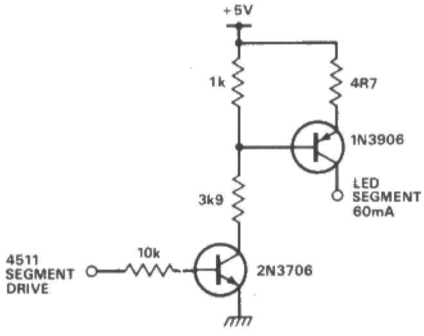

Fig. 8 Circuit diagram of boosted LED driver

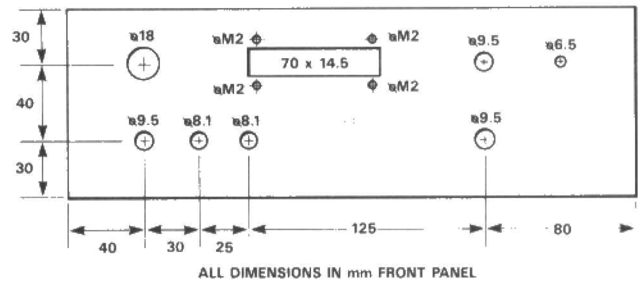

Fig. 9 Front panel drilling instructions

HOW IT WORKS

Input Amplifier (Fig 1): This comprises an input attenuator followed by a super source-follower (Q1, Q2) and an amplifier/buffer (Q3, Q4). This outputs the signal at a TTL compatible level up to about 30MHz. The counter (un-prescaled) will count beyond that frequency but accuracy becomes suspect and 30MHz is regarded as the upper limit for the low range. The input amp frequency response (at prescaler compatible levels) is limited only by the BF241's bandwidth of up to 450MHz, well beyond the prescales limitations.

Prescaling and gating (Fig 3): Output from Q4 is fed simultaneously to IC1 (a SP8629 ÷100 chip with an upper limit of about 200MHz and 100mV sensitivity) and IC2 (a TTL Schmitt gate which gives final 'squaring-up' of the un-prescaled signal). IC2 also selects either the 'straight-through' or 'prescaled' signal.

Circuit timing: IC16 is the clock oscillator/divider operating at a frequency of 3.2768MHz (a readily available and cheap crystal) and outputs a frequency of 400Hz to IC15 which controls the digit-strobe transistors (Q5-12) and output latches (ICs7-10).

The carry-out output of IC15 is further divided by ICs 13,14, the Q1 and Q5 outputs of IC13 controlling the signal gate flip/flop IC12b.

Q5 output of IC13 strobes the latch enable inputs of ICs7-10. Q7 output of IC13 resets IC13 and counter ICs3-6 to zero.

Display: Output is in 8 digit form strobed as above at 400Hz. Display enable is controlled by IC12a to blank leading zeros as follows: IC12a is reset low by output Q9 of IC15. Display driver IC11 is therefore disabled.

As IC15 strobes through the digits from MSD to LSD a high level on any of the BCD lines is detected by diodes D1-4 and sets IC12a high so enabling the display from that digit on (until IC12a is again reset by Q9 of IC15).

If no high level is detected then IC12a is set by output Q7 of IC15 (via D8) so enabling display of the least significant zero.

Positions of decimal points are selected by range switch via diodes D17-20 which switch power to the relevant decimal point via transistor Q13.

It must be noted however that due to the fairly low output current capacity of the 4511 digit driver high efficiency LED displays would be preferable; normal LEDs being somewhat dim but quite adequate in use provided the display is shaded from direct glare.

The power supply is of straight-forward design supplying a regulated 5V at up to 200mA.

The Q4 output of IC16 is taken to IC18, a 4040 counter which, from the 204800Hz input frequency provides 11 switchable squarewave outputs in the range 100-102400Hz. Transistor Q14 provides a low impedance output at TTL levels.

source frequency left running for an hour or so. Any further adjustment after that time should be very minor, if any. The TTL outputs can be switched through and checked for correct frequency on the low range.

The ranges are approximately:

Low — 0 to 30MHz at 1Hz resolution.
High — 0 to 200MHz at 100Hz resolution.

All readings are ± 1 least significant digit and are subject to the short and long term stability of the crystal oscillator.

The input attenuator allows the reading of very high voltages, from valved circuits for example, but the attenuation may be adjusted as required by changing the value of R2. Input sensitivity is around 350mV rms. By switching the input attenuator switch to 'O/P' the TTL output frequency may be read off directly.

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OOPS!

Burglar Buster (December 1988)
The foil part of the component overlay for the basic alarm (Fig. 1) was printed the wrong way around. It should be rotated through 180° as in Fig. 5. In Fig. 4a, Q3 is shown with its collector connected to the emitter of Q4. This is wrong — it should be connected to R5 and the base of Q4 as on the PCB overlay.

Audio Design MOSFET Amp (May 1989)
For home constructors of the power amp PCB (Fig. 8), the copper area connecting the negative of C7, C14 and R20 is a 0V #2 connection and should be linked to the 0V #2 copper area at the junction of C16 and C18+. Hart's kit PCB has a ground plane and no mod is necessary. Note that the preset at the bottom right of Fig. 8 takes the place of an external RV3 rheostat when bench testing and is not normally required. In Fig. 7 R14 is not shown — it should be in series in the negative feedback line between C8 and D3. Also in the parts list C20 is 100uF and R9 is 2k2.

Bench Power Supply (May 1989)
In the Parts List, Q3,4 should be BC237 not BC307. The value in the circuit diagram is correct.

How To MIDI A Piano (June 1989)
In Fig. 5 the connection from pin 19 of IC8 (MREQ) should go to pin 12 of IC7a, not pin 13 as shown. The component overlay is correct.

MIDI Patchbay (July 1989)
Figure 3 shows Q1-6 as npn transistors. They should in fact be pnp and their emitters should be connected to R2-12 respectively (R12 is unlabelled). Although the bases are all connected together they should not be connected to their emitters.

Reflex Action (July 1989)
Two lines in the listing on page 30 need amendment. Line 180 should read

```
180 PRINT "Enclosure volume=";vb:PRINT"tuned to";fb;"Hz":PRINT"  -3db at ": f3:PRINT "Ripple=";r;"db"
```

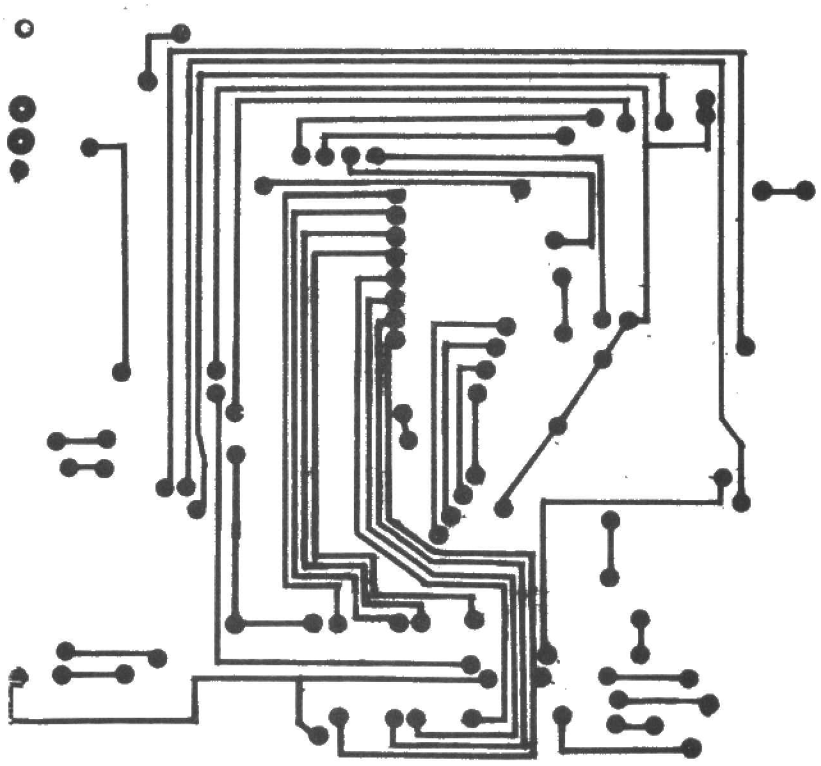
Line 280 should read

```
280 1=(2700*a)/(vb*fb  2))-0.96*(a  0.5)
```

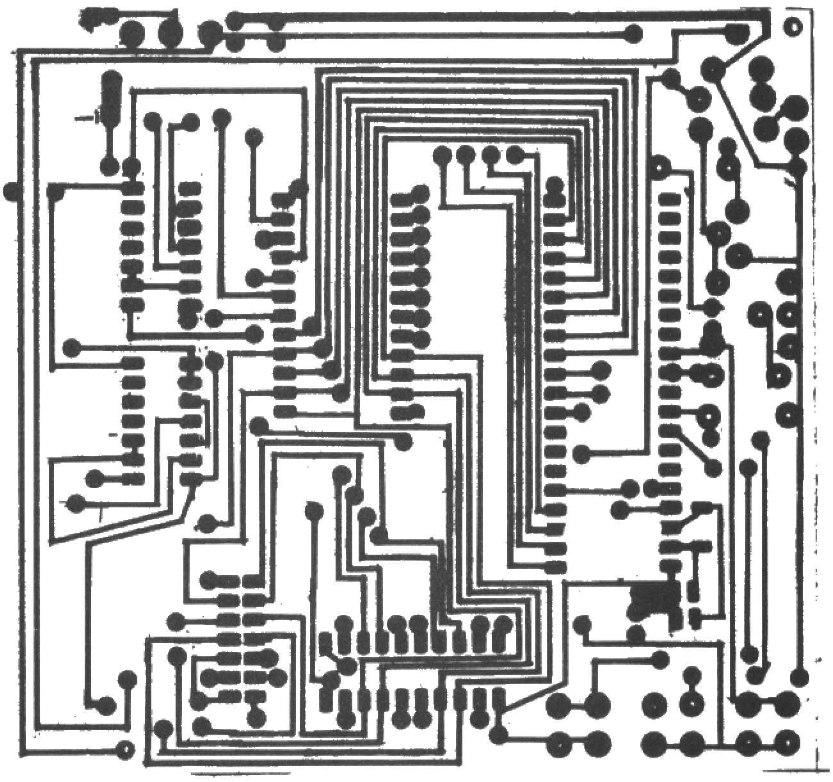
Chronoscope Revisited (September 1989)
In the paragraph headed 'Connections', D10 should read LED8 (on the sensor board). Also in Fig. 2, IC10 is shown reversed. The notch should be next to R49.

Field Power Supply (September 1989)
Figure 2 was printed with the artwork densities reversed, rendering a trifle tricky to interpret. It was reprinted together with a omitted col winding data on P62 of the October 1989 issue. A free photocopy is available from ETI Editorial on receipt of an SAE.

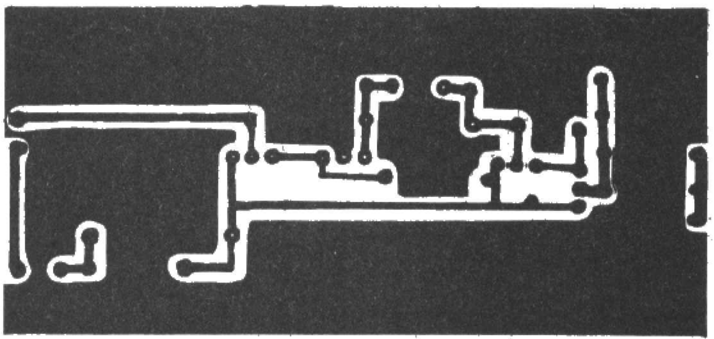
PCB FOIL PATTERNS



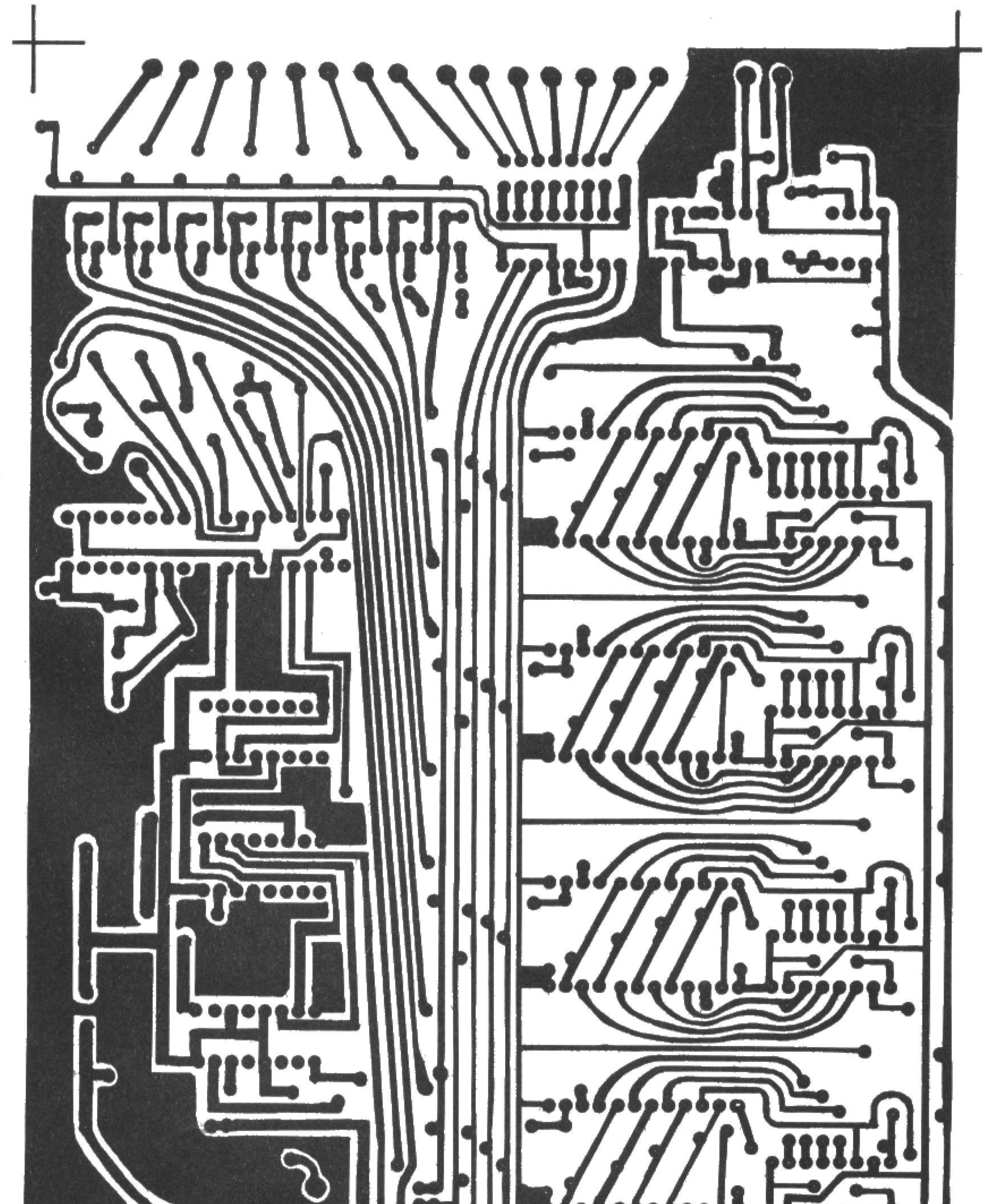
The serial logic scope topside foil



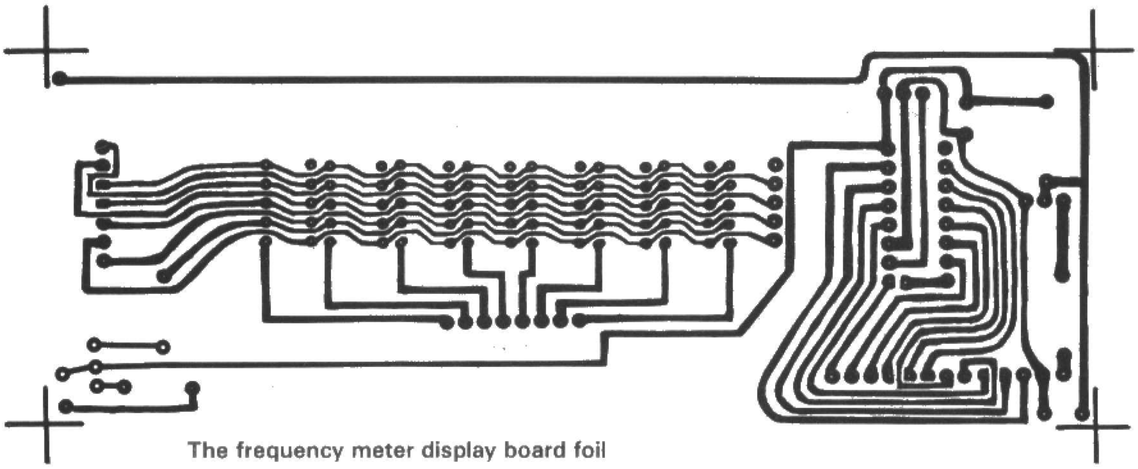
The serial logic scope copperside foil



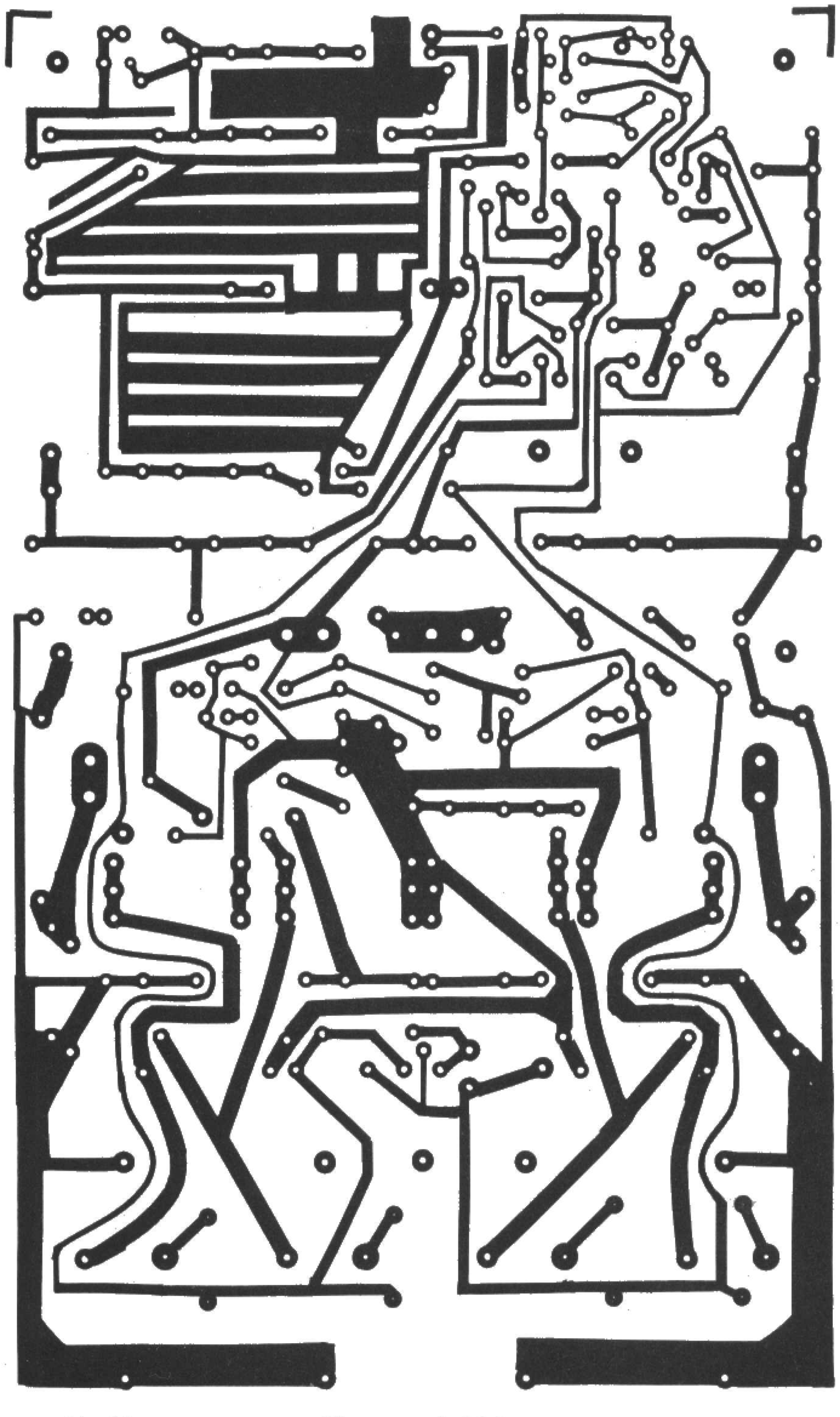
The frequency meter input amplifier foil



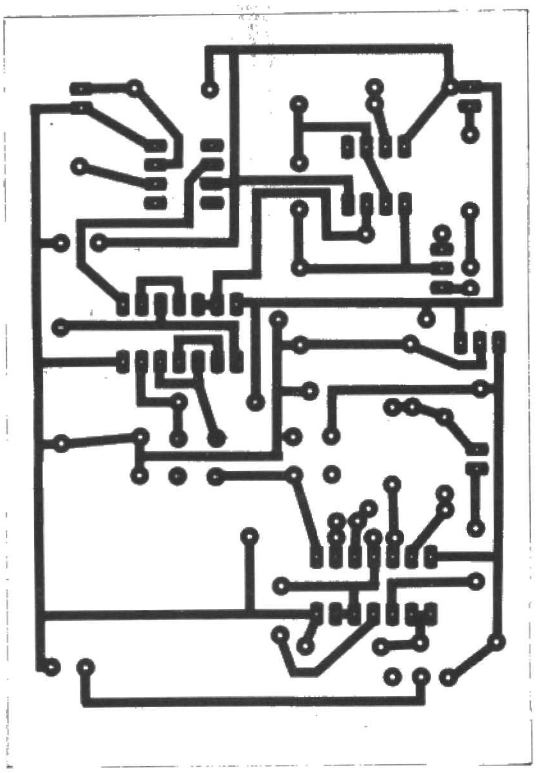
The frequency meter mail board foil



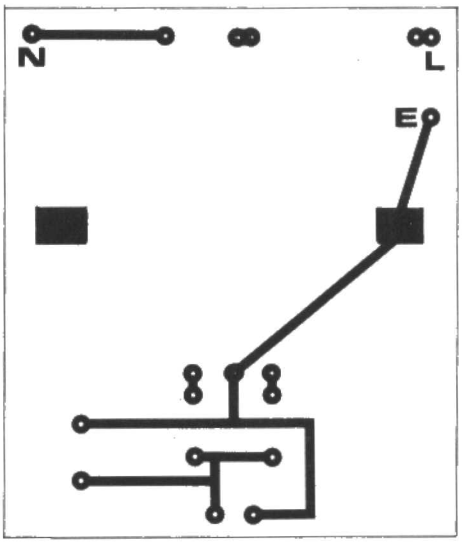
The frequency meter display board foil



The Virtuoso power amplifier upgraded foil pattern



The smoke alarm main foil



The smoke alarm power supply foil

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NEXT MONTH

The December issue ETI is the first of our oh-so-generous FREEBIE give-away issues — we strongly recommend an early visit to your local neighbourhood newsagent to reserve your copy before they all go.

On the December cover we'll be giving away a bag of components for you to build your very own surveillance bug.

In January there will be a PCB with enough space to construct two such bugs, plus a telephone surveillance device, plus our counter-surveillance spy catcher. Outstanding value for nothing, we think you'll agree!

Then with the February issue of ETI we'll be giving away an extra special issue of ETI — absolutely free, no catches, no strings attached, honest guv. How do we do it? Ten per cent inspiration, eighty per cent perspiration and the rest in used fivers. And gallons of coffee.

But we digress. Back in the December issue there's plenty to keep you busy while you tune in to your free bug. Build a digital noise generator — useful for testing or for sound FX. Build the Pedal Power project to feed a line of guitar effects as well as pre-amping the axe itself. Beginners can construct an alarm to announce the failure of mains power.

We'll be looking at safety — the dangers of home construction and the points often missed even on professional gear. The Patent Office comes under scrutiny — is a patent worth the bother and how do you get one if it is?

Plus we'll have reviews of EPROM Programmers, the return of our reader's circuits pages, and much much more.

So don't get left out in the cold — get your copy of the December ETI — out November 3rd.

The above articles are in preparation but circumstances may prevent publication

COMPETITION

Thanks to Rock Circus, The Tussauds Group and the sponsors Fuji Film, we have six pairs of tickets to Rock Circus (see pages 18-20). Although strongly tempted to hang on to them ourselves, we've decided to give them away to six readers who can complete the classic album titles below and send the missing words on a postcard to. ETI Rock Circus Competition, Argus House, Boundary Way, Hemel Hempstead HP2 7ST.

You need to move fast — the tickets are valid only until December 31st so we'll close the competition on October 17th and post the tickets to the winners that very day. Only one entry per person.

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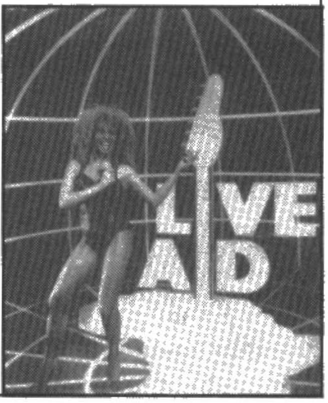

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